AD-A069 108

AD

AD-E400 299

TECHNICAL REPORT ARLCD-TR-78026

ANALYSIS OF A COMPRESSIBLE FLUID SOFT RECOIL (CFSR) CONCEPT APPLIED TO A 155 MM HOWITZER

BJORN L. HOFGAARD

MARCH 1979

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCD-TR-78026	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ANALYSIS OF A COMPRESSIBLE FLUID SOFT RECOIL (CFSR) CONCEPT APPLIED TO A 155 MM HOWITZER		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Bjorn L. Hofgaard		8. CONTRACT OR GRANT NUMBER(s) AMCMS Code 662603.H780011
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARRADCOM Weapons Division, LCWSL Dover, NJ 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Project No. 1W662603AH78
11. CONTROLLING OFFICE NAME AND ADDRESS US ARRADCOM ATTN: DRDAR-TSS Dover, NJ 07801		12. REPORT DATE MARCH 1979
		13. NUMBER OF PAGES 96
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) US ARRADCOM Weapons Division, LCWSL Dover, NJ 07801		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Compressible fluid
Bulk modulus
Compressibility
Coefficient of flow
Liquid flow equations
Variable buffer orifice
Recoil mechanism
Recoil equations
High pressure seals
Cylinder expansion
Energy absorbtion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A mathematical model analyzes a compressible fluid soft recoil (CFSR) concept applied to a 155 mm howitzer. The model addresses the relationships between volume and pressures in a compressible fluid, the forces, deflections, and stresses in the walls of a cylinder which is designed to expand elastically, and the forces and velocities of the recoiling mass. The mathematical model is used with a computer to optimize sizes, pressures, and stresses of the recoil mechanism.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Mr. Robert H. Coberly in setting up the mathematical model, Mr. Philip D. Benzkofer in running the digital computer program, Mr. Joseph E. Wilson in running the analog computer program, Prof. Arthur P. Boresi for doing the finite elements study, Dr. Rao Yalamanchili for advising on several matters, and Mr. Walter Pape for giving invaluable guidance.

TABLE OF CONTENTS

TABLES

FIGURES

INTRODUCTION

Attempts are being made to simplify soft recoil artillery mechanisms, to increase their reliability, and to reduce their need for costly and time-consuming maintenance and rebuild programs.

One approach proposed to accomplish these ends consists of storing the needed operating power or run-up energy partially in an elastically-compressed fluid and partially in elastically-expanding cylinder walls of the recoil mechanism itself. This compressible fluid soft recoil (CFSR) mechanism contains no mechanical springs, gas, replenishers, or recuperators. This results in tremendous simplification. The feasibility of this concept is analyzed in this technical report.

Not much work has been done in this field. Consequently, there are a multitude of unknown parameters and only a limited number of independent physical phenomena taking place which can be set up in mathematical form to solve these unknowns. The unknown parameters include: diameters, lengths, shapes, thicknesses, and orifice sizes; constants, coefficients, physical relationships, and physical properties; pressures, forces, pressure areas, and stresses; fluid flows, volumes, and weights; velocities, required energies, etc. Some of the less critical parameters, therefore, had to be arbitrarily estimated, and some variables had to be fixed.

The basic CFSR concept is thoroughly explained in reference 1. In addition, a brief description is included in the following paragraphs.

In a soft recoil mechanism, a force causes the recoiling mass to move forward before the round is fired. Firing is initiated when a predetermined level of kinetic energy is reached, which is about half of the energy transmitted to the breech by the firing forces. By the time the recoiling mass has returned to the latch position and restored the working energy, all of the firing energy has been dissipated without any large forces being transmitted to the rest of the structure. This permits the size and weight of the remaining structure to be greatly reduced.

In the CFSR concept described by this report, only part of the force which sends the recoiling mass forward before firing is derived from a liquid which has been elastically compressed.

An additional force is imparted by the outer walls of the recoil cylinder which is designed to expand under pressure and store energy elastically.

The expanding cylinder wall theory is a new concept which is evaluated in conjunction with the basic CFSR principle.

DEVELOPMENT AND THEORY OF THE MATHEMATICAL MODEL

A mathematical model is used primarily to identify and measure significant relationships between controlling parameters. When developing a model, only the most important variables are considered and any secondary effects are generally neglected. Inclusion of too much detail tends to obscure the important relationships, to reduce ability to examine sensitivity to varying input data, and to increase the time required for model development.

In the following paragraphs the most important parameters are optimized (fig. 1, 2).

Determination of Cylinder Expansion

For a thick-walled cylinder with capped ends, having inner and outer radii of r_1 and r_2, respectively, and subjected to an internal pressure, P_1, and an external pressure, P_2, the tangential, longitudinal, and radial stresses are defined, respectively, by the following equations (ref. 2):

$$\sigma_t = \frac{P_1 r_1^2 - P_2 r_2^2 + (r_1^2 r_2^2/\rho^2)(P_1 - P_2)}{r_2^2 - r_1^2}, \quad (1)$$

$$\sigma_\ell = \frac{P_1 r_1^2 - P_2 r_2^2}{r_2^2 - r_1^2}, \quad (2)$$

$$\sigma_r = \frac{P_2 r_2^2 - P_1 r_1^2 + (r_2^2 r_1^2/\rho^2)(P_1 - P_2)}{r_2^2 - r_1^2}, \quad (3)$$

where p is the radius to an arbitrary element of the cylinder. The strain in the cylinder is given as

$$\varepsilon_t = \frac{1}{E}(\sigma_t - \nu\sigma_r - \nu\sigma_\ell) \tag{4}$$

(stresses are positive in tension) where ν is Poissons's ratio (0.287) and E is the modulus of elasticity 199.95×10^9 Pa (29×10^6 psi).

For a thick-walled cylinder with capped ends, having inner and outer radii of a and b, respectively, and subjected to an <u>internal</u> pressure only, then; $P_1 = P$, $r_1 = a$, $r_2 = b$ and $P_2 = 0$.

For $\rho = r_1 = a$

$$\sigma_t = \frac{b^2+a^2}{b^2-a^2} P \quad \text{tension}, \tag{5}$$

$$\sigma_\ell = \frac{a^2}{b^2-a^2} P \quad \text{tension}, \tag{6}$$

$$\sigma_r = P \quad \text{compression}, \tag{7}$$

$$\varepsilon = \frac{\Delta a}{a} = \frac{1}{E}\left[\frac{b^2+a^2}{b^2-a^2} P + \nu P - \nu \frac{a^2}{b^2-a^2} P\right], \tag{8}$$

so

$$\Delta a = P \frac{a}{E}\left[\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu\right]. \tag{9}$$

For a thick-walled cylinder with capped ends, having inner and outer radii of c and d, respectively, and subjected to an <u>external</u> pressure only, then; $P_1 = 0$, $P_2 = P$, $r_1 = c$, $r_2 = d$.

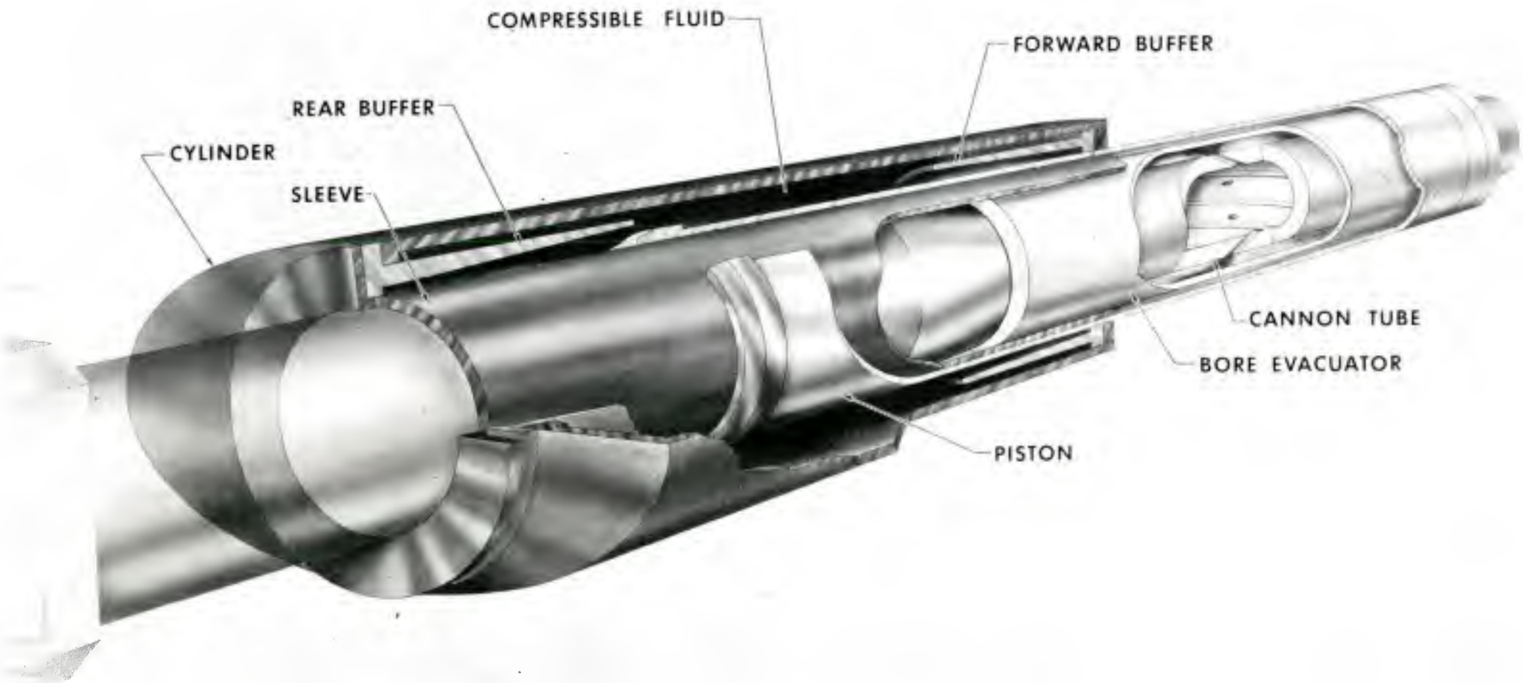


Figure 1. Compressible fluid soft recoil concept.

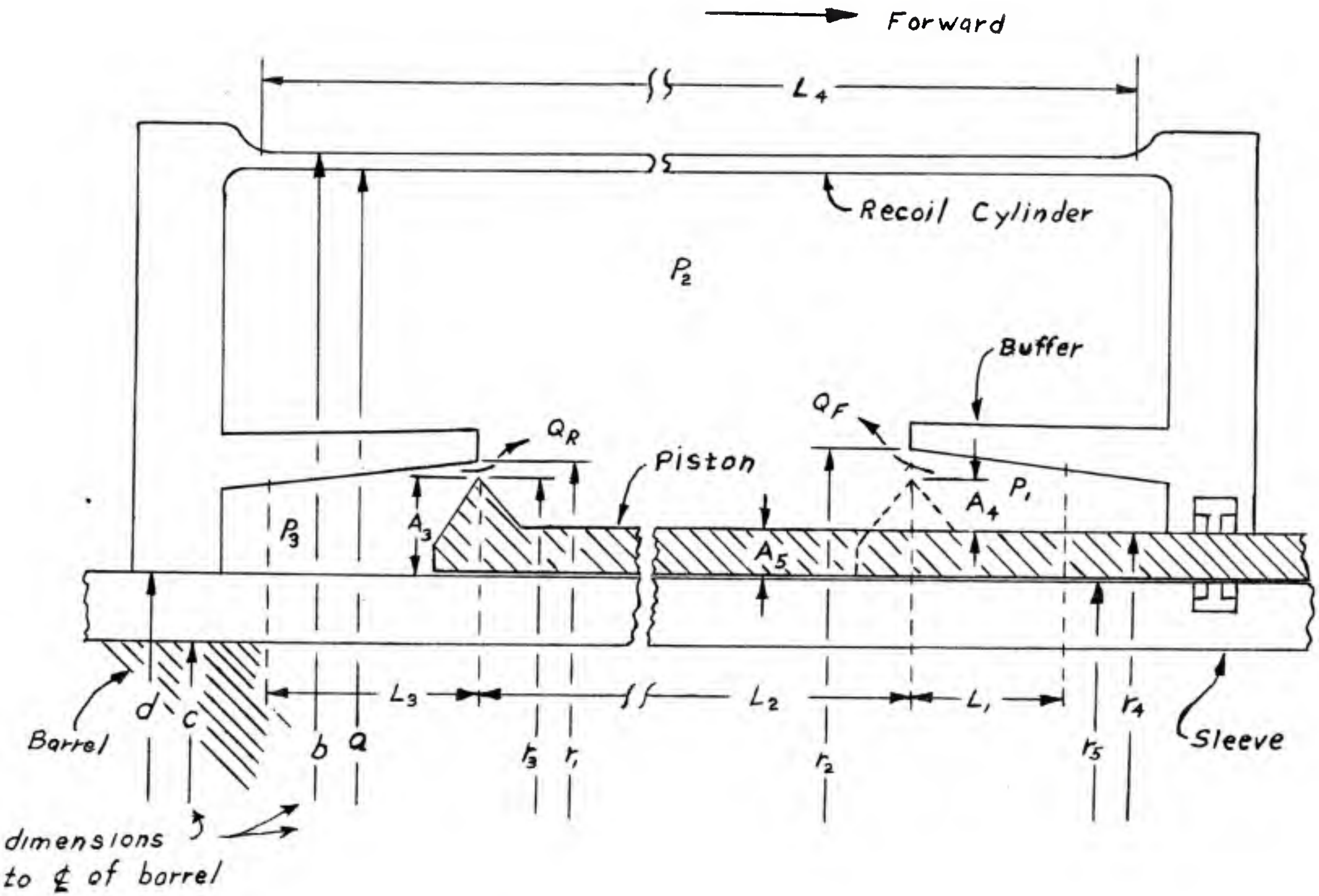


Figure 2. Schematic half section of recoil mechanism.

For $\rho = r_2 = d$

$$\sigma_t = -p \frac{d^2+c^2}{d^2-c^2} \quad \text{tension}, \tag{10}$$

$$\sigma_\ell = -P \frac{d^2}{d^2-c^2} \quad \text{tension}, \tag{11}$$

$$\sigma_r = P \quad \text{compression}, \tag{12}$$

$$\varepsilon_t = \frac{\Delta d}{d} = \frac{-P}{E}\left[\frac{d^2+c^2}{d^2-c^2} - \nu - \nu \frac{d^2}{d^2-c^2}\right], \tag{13}$$

or

$$\Delta d = -P \frac{d}{E}\left[\frac{d^2(1-\nu)+c^2}{d^2-c^2} - \nu\right]. \tag{14}$$

Define an effective spring rate, K_1 such that

$$2\pi(a+\Delta a)\ L_1 P_1 = K_1 \Delta a \tag{15}$$

where L_1 is the length of the cylinder on which the internal pressure, P_1 acts.

$$K_1 = 2\pi L_1 P_1 \left(\frac{a}{\Delta a} + 1\right) ,$$

but

$$\frac{a}{\Delta a} = \frac{E}{P_1} \frac{1}{\left[\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu\right]} , \tag{16}$$

thus

$$K_1 = \frac{2\pi L_1 E}{\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu} + 2\pi L_1 P_1 . \tag{17}$$

Similarly, define an effective spring rate, K_2 such that

$$2\pi(d+\Delta d)\ L_2 P_2 = -K_2 \Delta d \tag{18}$$

where L_2 is the length of the cylinder on which the external pressure, P_2 acts.

$$K_2 = 2\pi L_2 P_2 \left(-\frac{d}{\Delta d} - 1\right), \tag{19}$$

but

$$-\frac{d}{\Delta d} = \frac{E}{P_2} \frac{1}{\left(\frac{d^2(1-\nu)+c^2}{d^2-c^2} - \nu\right)} \quad ; \tag{20}$$

thus,

$$K_2 = \frac{2\pi L_2 E}{\frac{d^2(1-\nu)+c^2}{d^2-c^2} - \nu} - 2\pi L_2 P_2 \quad . \tag{21}$$

The mass associated with the internal pressure which is being expanded is $\pi(b^2-a^2)L_1\rho_S$ where ρ_S is the density of the material.

One equation of motion becomes

$$\pi(b^2-a^2)L_1\rho_S \frac{\ddot{Y}}{2} = \pi L_1 P_1 Y - \left(\frac{2\pi L_1 E}{\left[\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu\right]} + 2\pi L_1 P_1\right) \frac{Y-2a}{2} \tag{22}$$

where $Y=2(a+\Delta a)$ is the instantaneous value of the inner diameter. Δa and Δd are the radial expansions of the a and d radii.

and $\quad \Delta a = \frac{Y-2a}{2}$, $\ddot{Y} = 2\Delta\ddot{a}$.

Rewriting the equation of motion:

$$(b^2-a^2)\rho_S\Delta\ddot{a} = P_1 2a+P_1 2\Delta a - \frac{E2\Delta a}{[\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu]} - P_1 2\Delta a \tag{23}$$

or

$$(b^2-a^2)\rho_S\Delta\ddot{a} = 2aP - \frac{2\Delta aE}{[\frac{b^2+(1-\nu)a^2}{b^2-a^2} + \nu]} \; . \tag{24}$$

Similarly

$$(d^2-c^2)\rho_S\Delta\ddot{d} = -2dP - \frac{2\Delta dE}{[\frac{d^2(1-\nu)+c^2}{d^2-c^2} - \nu]} \; . \tag{25}$$

Effects of Compressibility

The physical volume (V) available to the fluid at any instant is:

$$V = \frac{\pi}{4} (Y^2 - Z^2)L_4 + A_5 (X - L_1 - L_2 - L_3) + V_0 - V_B \; . \tag{26}$$

X is the distance of piston travel from its rearmost position in the rear buffer (see Variable Buffer Orifice Area). See Symbols of Basic Engineering Values, Dimensions, and Physical Parameters for definitions of symbols. By definition, the bulk modulus, β, is:

$$\beta = - \frac{\Delta P}{\Delta V/V} \tag{27}$$

or

$$\Delta P = - \frac{\Delta V}{V} \beta \; . \tag{28}$$

In differential form with respect to time, t;

$$\frac{dP}{dt} = - \frac{\beta}{V} \frac{dV}{dt} \tag{29}$$

but

$$\frac{dV}{dt} = \frac{\pi L_4}{2} (Y\dot{Y} - Z\dot{Z}) + A_5 \dot{X} . \tag{30}$$

Then the basic equation becomes:

$$\dot{P}_2 = -\beta \frac{\frac{\pi L_4}{2} (Y\dot{Y} - Z\dot{Z}) + A_5 \dot{X}}{\frac{\pi L_4}{4} (Y^2 - Z^2) + A_5 (X - L_1 - L_2 - L_3) + V_0 - V_B} . \tag{31}$$

$Y = 2a + 2\Delta a$ $\qquad$ $Z = 2d + 2\Delta d$

$\dot{Y} = 2\Delta \dot{a}$ $\qquad$ $\dot{Z} = 2\Delta \dot{d}$ $\qquad$ $^*\beta = NP + 132{,}500$.

$Y^2 = 4(a + \Delta a)^2$ $\qquad$ $Z^2 = 4(d + \Delta d)^2$

The desired equation becomes:

$$^*\dot{P}_2 = - (NP_2 + 132{,}500) \frac{2\pi L_4 \left[(a + \Delta a) \Delta \dot{a} - (d + \Delta d) \Delta \dot{d}\right] + A_5 \dot{X}}{\pi L_4 \left[(a + \Delta a)^2 - (d - \Delta d)^2\right] + A_5 (X - L_1 - L_2 - L_3) + V_0 - V_B} . \tag{32}$$

*This formula is expressed in English units.

This equation applies only to P_2 during normal fire, when the piston is between the buffers. If the buffer volumes are added to the equation, this same equation can be applied to P_2 for all three firing conditions (normal, misfire, and cook-off). These additional volumes can be prefixed with controlling functions J, R, and U, to "switch" these portions on or off as the case may be, depending on the location of the piston.

Therefore, the final equation becomes:

$$*\dot{P}_2 = -(NP_2 + 132{,}500)\frac{2\pi L_4\left[(a + \Delta a)\,\Delta\dot{a} - (d + \Delta d)\,\Delta\dot{d}\right] + RA_5\dot{X} - J(A_4\dot{X} + Q_R) + U(A_4\dot{X} - Q_F)}{\pi L_4\left[(a + \Delta a)^2 - (d + \Delta d)^2\right] + A_5(X - L_1 - L_2 - L_3) + V_0 - V_B - J(A_3 + A_R)X + U(A_4 + A_F)(X - L_1 - L_2 - L_3)} \quad (33)$$

The equation for the pressure in the front buffer pocket, P_1, becomes:

$$*\dot{P}_1 = U(P_1N + 132{,}400)\frac{(A_4\dot{X} - Q_R)}{(A_4 + A_F)(L_1 + L_2 + L_3 - X)} \quad (34)$$

*These equations are expressed in English units.

The equation for the pressure in the rear buffer pocket, P_3, becomes:

$$*\dot{P}_3 = -J(P_3N + 132{,}500)\frac{(A_3\dot{X} + Q_R)}{(A_3 + A_R)X} \tag{35}$$

(see figure 2).

$J = 1$ when $X < L_3$
$J = 0$ when $X > L_3$

$R = 1$ when $X > L_3$
$R = 0$ when $X < L_3$

$U = 1$ when $X > L_2 + L_3$
$U = 0$ when $X < L_2 + L_3$

Recoil Equation

The recoil equation is

$$*M_R\ddot{X} = S(2.69\,P_3(.5) + 2.97\,P_1) + P_3\,A_3 - P_1\,A_4 - HB(t) - W_R \sin\gamma \tag{36}$$

where M_R and W_R are the mass and weight, respectively, of the recoiling parts. B(t) is the breech force (see Appendix A), and H is a control function that initiates B(t) when $\dot{X}=V_e$. P_3A_3 and P_1A_4 are forces on the piston. $*2.69P_3(.5)+ 2.97P_1$ is seal friction (see Appendix B), and S is a control function which changes the direction of the friction force when the piston changes direction. γ is the angle of elevation of the weapon.

---

*These formulas are expressed in English units.

Flow Equations

The classical flow equations applied to the buffers, become:

$$Q_F = A_F K_F \sqrt{\frac{2g}{\omega} \left| (P_1 - P_2) \right|} \qquad \text{sign of } P_1 - P_2 = \text{sign of } Q_F \tag{37}$$

$$Q_R = A_R K_R \sqrt{\frac{2g}{\omega} \left| (P_3 - P_2) \right|} \qquad \text{sign of } P_3 - P_2 = \text{sign of } Q_R \tag{38}$$

where Q is the rate of flow in in^3/sec, A is the orifice area at any instant, K is coefficient of discharge, ω is the specific weight of the fluid, and P is the pressure.

For development of this formula and a discussion of coefficient of discharge see Appendix C.

Variable Buffer Orifice Area

Front Buffer Area A_F

Assuming a straight linear taper (see fig 3):

$$\frac{r_2 - r_3}{L_1} = \frac{r_X - r_3}{L_1 + L_2 + L_3 - X} \tag{39}$$

$$(r_2 - r_3)\left(1 + \frac{L_2}{L_1} + \frac{L_3}{L_1} - \frac{X}{L_1}\right) = r_X - r_3 \tag{40}$$

$$r_2 + \frac{r_2 L_2}{L_1} + \frac{r_2 L_3}{L_1} - \frac{r_2 X}{L_1} - r_3 - \frac{r_3 L_2}{L_1} - \frac{r_3 L_3}{L_1} + \frac{r_3 X}{L_1} + r_3 = r_X \tag{41}$$

$$G_F = r_2 - r_3 \tag{42}$$

$$A_1 = \pi \left(r_2^2 - r_3^2\right) \tag{43}$$

$$r_X = G_F \frac{L_2}{L_1} + G_F \frac{L_3}{L_1} - G_F \frac{X}{L_1} + r_2 \tag{44}$$

$$r_X = \frac{G_F}{L_1}(L_2+L_3-X) + r_2 \tag{45}$$

$$A_F = \pi(r_X^2-r_3^2) \tag{46}$$

$$A_F = \pi[(\frac{G_F}{L_1}(L_2+L_3-X)+r_2)^2-r_3^2] \tag{47}$$

$$A_F = [\frac{G_F{}^2}{L_1^2}(L_2+L_3-X)^2 + \frac{2G_Fr_2}{L_1}(L_2+L_3-X) + r_2^2-r_3^2] \tag{48}$$

$$A_F = A_1 + \frac{\pi G_F{}^2}{L_1^2}(L_2+L_3-X)^2 + \frac{2\pi G_Fr_2}{L_1}(L_2+L_3-X) \tag{49}$$

$$A_F = A_1 + \frac{\pi G_F{}^2}{L_1^2}(L_2+L_3)^2 + \frac{2\pi G_Fr_2}{L_1}(L_2+L_3) - [\frac{\pi G_F{}^2 2}{L_1^2}(L_2+L_3) + \frac{2\pi G_Fr_2}{L_1}]X + \frac{\pi G_F{}^2}{L_1^2}X^2 \tag{50}$$

Rear Buffer Area A_R

Assuming a straight linear taper (see fig 4):

$$\frac{r_1-r_3}{L_3} = \frac{r_X-r_3}{X} \tag{51}$$

$$r_X = \frac{r_1X-r_3X+L_3r_3}{L_3} \tag{52}$$

$$G_R = r_1-r_3 \tag{53}$$

$$A_R = \pi(r_X^2-r_3^2) \tag{54}$$

$$A_R = \pi[(G_R\frac{X}{L_3} + r_3)^2-r_3^2] \tag{55}$$

$$A_R = \pi[G_R{}^2\frac{X^2}{L_3^2} + 2G_R\frac{X}{L_3}r_3 + r_3^2-r_3^2] \tag{56}$$

$$A_R = \frac{2\pi G_Rr_3}{L_3}X + \frac{\pi G_R{}^2}{L_3^2}X^2 \ . \tag{57}$$

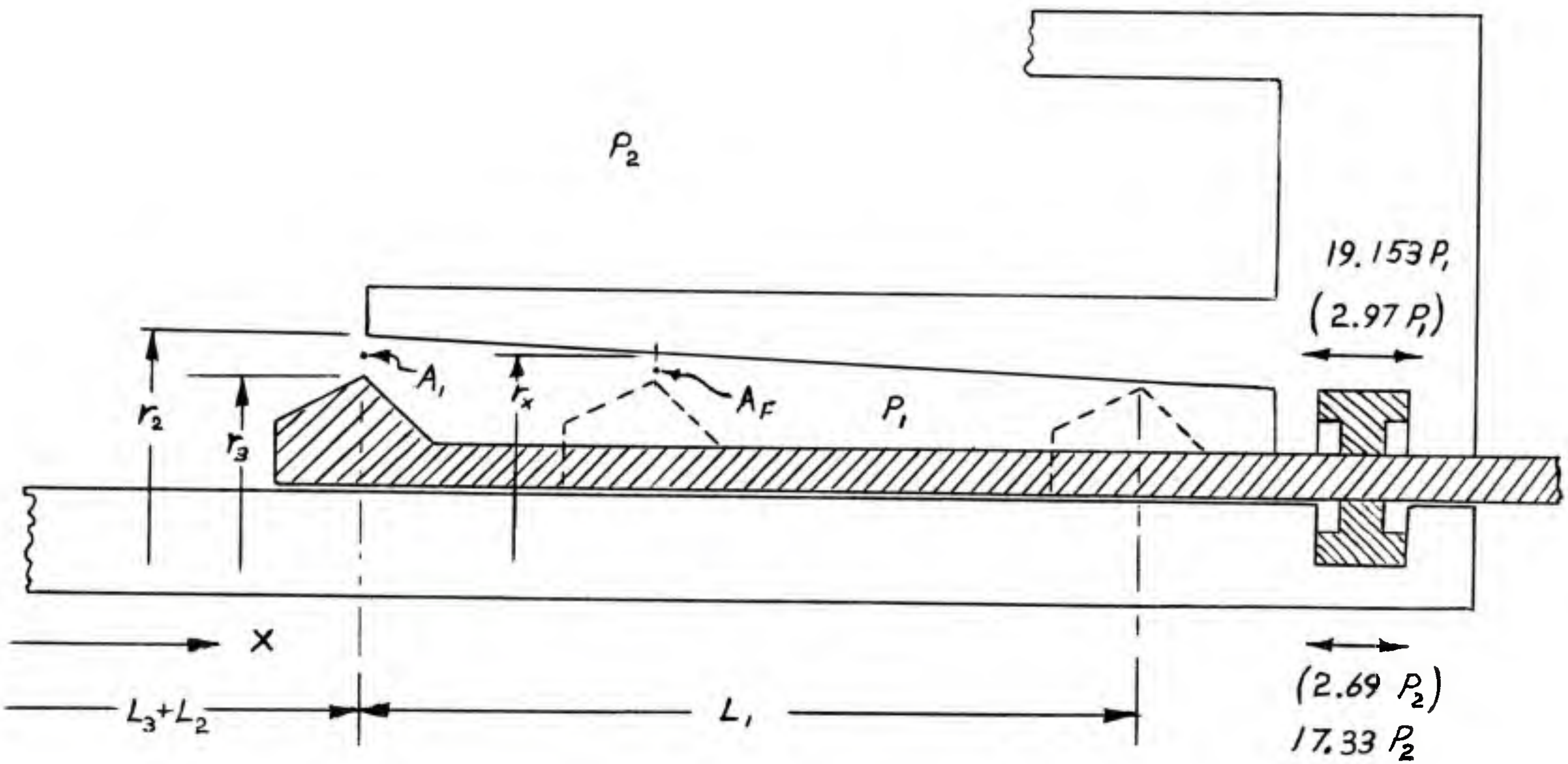


Figure 3. Front buffer.

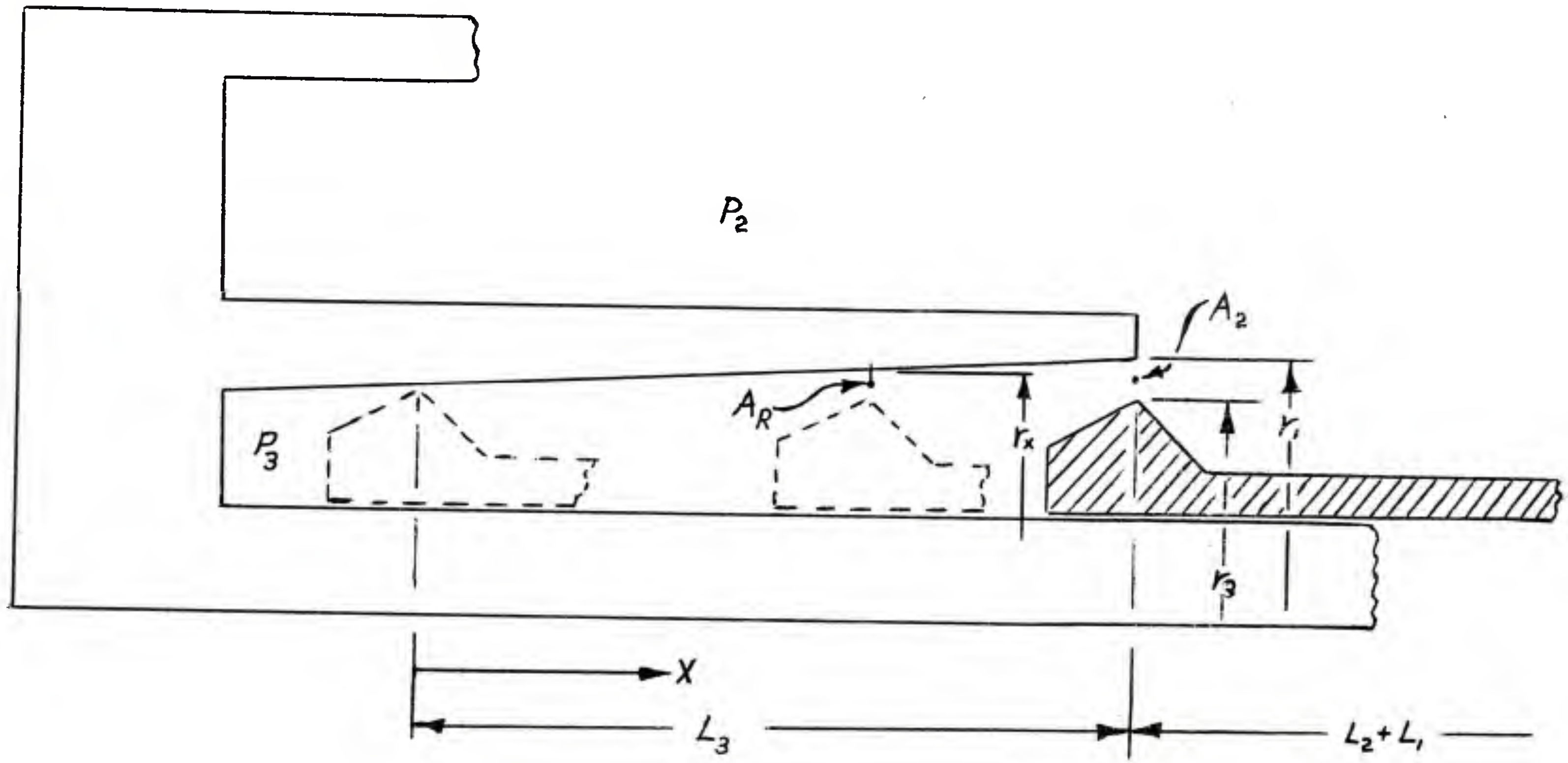


Figure 4. Rear buffer.

Amount of Energy the System is Able to Store

Energy stored in the compressed fluid, E_f, is:

$$E_f = \int P\,dV \tag{58}$$

where V is the total fluid volume at any instant, and P is the variable pressure.

$$V = \frac{\pi}{4}(Y^2 - Z^2)\,L_4 + A_5\,(X - L_1 - L_2 - L_3) + V_0 - V_B. \tag{59}$$

X is the distance of piston travel from the rearmost position in the rear buffer. A_5 is the effective net piston area. L_4 is the effective length of both inside (Z) and outside (Y) cylinders.

$$\Delta P = -\frac{\Delta V}{V}\beta \qquad \text{(eqn 28)} \tag{60}$$

$$\frac{dP}{dt} = -\frac{\beta}{V}\frac{dV}{dt} \tag{61}$$

$$dV = -\frac{V}{\beta}\frac{dP}{dt}\,dt \qquad {}^*\beta = NP_2 + 132{,}500\ . \tag{62}$$

Now if these last two equations are substituted into the energy equation one has:

$$^*E_f = \int P_2 - \frac{V}{(NP_2 + 132{,}500)}\frac{dP}{dt}\,dt \tag{63}$$

or

$$^*E_f = -\int \frac{VP_2\dot{P}_2}{NP_2 + 132{,}500}\,dt\ . \tag{64}$$

Energy stored in the flexible cylinder walls, E_c, is:

$$E_c = \int 2(a+\Delta a)\pi L_4 P\,d(\Delta a) + \int 2(d+\Delta d)\pi L_4 P\,d(\Delta d)\ , \tag{65}$$

$$Y = 2(a+\Delta a) \qquad Z = 2(d+\Delta d)$$

$$\dot{Y} = 2\Delta\dot{a} \qquad \dot{Z} = 2\Delta\dot{d}$$

---

*These formulas are expressed in English units.

$$E_C = \int Y\pi L_4 P \frac{d(\Delta a)}{dt} dt + \int Z\pi L_4 P \frac{d(\Delta d)}{dt} dt \ , \tag{66}$$

$$E_C = \pi L_4 \int YP\Delta\dot{a}dt + \pi L_4 \int ZP\Delta\dot{d}dt \ , \tag{67}$$

and finally,

$$E_C = \frac{\pi L_4}{2} \int Y\dot{Y}P_2 dt + \frac{\pi L_4}{2} \int Z\dot{Z}P_2 dt \ , \tag{68}$$

or

$$E_C = 2\pi L_4 \int (a+\Delta a)\Delta\dot{a}P_2 dt + 2\pi L_4 \int (d+\Delta d)\Delta\dot{d}P_2 dt \ . \tag{69}$$

Summary of Mathematical Model

A summary of the model, using all the physical phenomena taking place in the recoil mechanism, may be expressed by the following ten equations. The equations include the ten unknown variables defined in the next section.

$$Q_F = A_F K \sqrt{\frac{2g}{\omega} |(P_1-P_2)|} \qquad \text{sign of } (P_1-P_2) = \text{sign of } Q_F \tag{70}$$

$$Q_R = A_R K \sqrt{\frac{2g}{\omega} |(P_3-P_2)|} \qquad \text{sign of } (P_3-P_2) = \text{sign of } Q_R \tag{71}$$

$$A_F = A_1 + \frac{\pi G_F{}^2}{L_1^2}(L_2+L_3)^2 + \frac{2\pi G_F r_2}{L_1}(L_2+L_3) - [\frac{\pi G_F{}^2 2}{L_1^2}(L_2+L_3) + \frac{2\pi G_F r_2}{L_1}]X + \frac{\pi G_F{}^2}{L_1^2} X^2 \tag{72}$$

$$A_R = \frac{2\pi G_R r_3}{L_3} X + \frac{\pi G_R{}^2}{L_3^2} X^2 \tag{73}$$

$$(b^2-a^2)\,\rho_S \Delta\ddot{a} = 2aP_2 - \frac{2E\Delta a}{\left[\frac{b^2+(1-\nu_S)a^2}{b^2-a^2} + \nu_S\right]} \tag{74}$$

$$(d^2-c^2)\,\rho_S \Delta\ddot{d} = -2dP_2 - \frac{2E\Delta d}{\left[\frac{d^2(1-\nu_S)+c^2}{d^2-c^2} - \nu_S\right]} \tag{75}$$

$$*\dot{P}_1 = U(P_1 N + 132{,}500)\,\frac{(A_4\dot{X} - Q_R)}{(A_4 + A_F)\,(L_1 + L_2 + L_3 - X)} \tag{76}$$

$$*\dot{P}_2 = -(NP_2 + 132{,}500)\,\frac{2\pi L_4\left[(a + \Delta a)\,\Delta\dot{a} - (d + \Delta d)\Delta\dot{d}\right]}{\pi L_4\left[(a + \Delta a)^2 - (d + \Delta d)^2\right] + A_5\,(X - L_1 - L_2 - L_3)}$$

$$\frac{+RA_5\dot{X} - J(A_4\dot{X} + Q_R) + U(A_4\dot{X} - Q_F)}{+V_0 - V_B - J(A_3 + A_R)X + U(A_4 + A_F)\,(X - L_1 - L_2 - L_3)} \tag{77}$$

$$*\dot{P}_3 = -J(P_3 N + 132{,}500)\,\frac{(A_3 X + Q_R)}{(A_4 + A_R)X} \tag{78}$$

$J = 1$ when $X < L_3$
$J = 0$ when $X > L_3$

$R = 1$ when $X > L_3$
$R = 0$ when $X < L_3$

$U = 1$ when $X > L_2 + L_3$
$U = 0$ when $X < L_2 + L_3$

$$*M_r\ddot{X} = S\,(2.69\;(.5)\;P_3 + 2.97\,P_1) + P_3 A_3 - P_1 A_4 - HB(t) - W_R \mathrm{SIN}_\gamma \tag{79}$$

$S = -1$ when $\dot{X} > 0$
$S = +1$ when $\dot{X} < 0$

$H = 1$ when $\dot{X} \geq Ve$
$H = 0$ when $\dot{X} < Ve$

Ten Unknown Variables

The relationships of the following ten unknown variables are expressed by the mathematical model. Fixing their relationships will unlock other relationships and parameters.

*These equations are expressed in English units.

Q_F = Fluid flow through annular orifice in front buffer

Q_R = Fluid flow through annular orifice in rear buffer

P_1 = Pressure in front buffer area

P_2 = Pressure in recoil cylinder

P_3 = Pressure in rear buffer area

A_F = Variable orifice area in front buffer

A_R = Variable orifice area in rear buffer

X = Distance of piston travel from its innermost position in rear buffer

Δa = Radial expansion of inside radius of outside recoil cylinder

Δd = Radial expansion of outside radius of inside sleeve

Other Relationships of Important Parametric Design Values

$$A_1 = \pi(r_2^2 - r_3^2) \tag{80}$$

$$A_2 = \pi(r_1^2 - r_3^2) \tag{81}$$

$$A_3 = \pi(r_3^2 - r_5^2) \tag{82}$$

$$A_4 = \pi(r_3^2 - r_4^2) \tag{83}$$

$$A_5 = \pi(r_4^2 - r_5^2) = A_3 - A_4 \tag{84}$$

$$G_F = r_2 - r_3 \tag{85}$$

$$G_R = r_1 - r_3 \tag{86}$$

$$\sigma_t = \frac{(b^2+a^2)}{(b^2-a^2)} P_2 \qquad \text{(see ref 2)} \tag{87}$$

$$\sigma_a = \frac{a^2}{b^2-a^2} P_2 \tag{88}$$

$$\sigma_r = -P_2 \tag{89}$$

$$2\sigma_e^2 = (\sigma_t - \sigma_r)^2 + (\sigma_r - \sigma_a)^2 + (\sigma_a - \sigma_t)^2 \tag{90}$$

$$V = \pi(a^2 - d^2)L_4 + A_5\left[X_0 - (L_1 + L_2 + L_3)\right] + V_0 - V_B \tag{91}$$

$$V_B = (L_4 - L_2)\ ({R_{av}}^2 - {r_{ab}}^2)\pi \tag{92}$$

$$W_f = V_1 \omega \tag{93}$$

$$^*E_f = -\int \frac{VP_2\dot{P}_2}{NP_2 + 132{,}500}\, dt \tag{94}$$

$$E_C = \frac{\pi L_4}{2}\int Y\dot{Y}P_2 dt + \frac{\pi L_4}{2}\int Z\dot{Z}P_2 dt \tag{95}$$

$$^*X_0:\quad P = \frac{\pi L_4\left[(2a + \Delta a)\Delta a + (2d - \Delta d)\Delta d\right] + A_5(X_0 - X)}{\pi L_4\,(a^2 - d^2) + A_5\left[X_0 - (L_1 + L_2 + L_3)\right] - V_B + V_0}\ (NP - 132{,}500) \tag{96}$$

$$C = \frac{100 \quad -\pi L_4\left[(2a + \Delta a)\Delta a + (2d - \Delta d)\Delta d\right] + A_5(X_0 - X)}{\pi L_4\ (a^2 - d^2) + A_5\left[X_0 - (L_1 + L_2 + L_3)\right] - V_B + V_0} \tag{97}$$

$$P_{cr} = \frac{\pi^2 EI}{4(L_1 + L_2 + L_3 - X_{min})^2} \qquad \text{(Euler's formula)} \tag{98}$$

$$I = \frac{\pi(r_4^4 - r_5^4)}{4} \tag{99}$$

$$P_{pt} = A_5 P_2 \tag{100}$$

or

$$= A_3 P_3 - A_4 P_2 \tag{101}$$

---

*These equations are expressed in English units.

Symbols of Basic Engineering Values, Dimensions and Physical Parameters

L_1 = run-up distance in front buffer

L_2 = run-up distance for normal firing (between buffers)

L_3 = run-up distance in rear buffer

L_4 = length of outside flexible cylinder

r_1 = inside radius of rear buffer at its entrance

r_2 = inside radius of front buffer at its entrance

r_3 = outside radius of piston over orifice cam

r_4 = outside radius of piston sleeve

r_5 = inside radius of piston sleeve

a = inside radius of outside flexible cylinder

b = outside radius of outside flexible cylinder

c = inside radius of sleeve

d = outside radius of sleeve

V_B = approximate volume of fluid the buffers displace

V_0 = extra fluid volume in associated container (if necessary)

V = total fluid volume in recoil cylinder

W_f = total weight of fluid

V_e = firing velocity of recoil mechanism or maximum run-up velocity

V_1 = piston velocity (going into latch)

V_m = minimum piston velocity (misfire only)

P_1 max = maximum pressure in front buffer area

P_2 max = maximum pressure in recoil cylinder

P_3 max = maximum pressure in rear buffer area

P min = minimum pressure in any of the volumes

P init = initial pressure in all volumes when piston is at a point of latch

X_0 = the value of X calculated for the point where all pressures are zero

X_{p_0} = the value of X at the point where $P_2 = 0$ (taken from computer data)

X max = maximum value of X in front buffer

X min = minimum value of X in rear buffer

E_f = amount of energy absorbed in the fluid

E_c = amount of energy absorbed in the cylinder walls

E_{br} = impulse energy at breech

Imp = maximum firing impulse at breech

σ_t = tangential stress in recoil cylinder walls

σ_a = axial stress in recoil cylinder walls

σ_r = radial stress in recoil cylinder walls

σ_e = equivalent stress in recoil cylinder walls

A_1 = annular cross-sectional area between front buffer entrance and piston cam

A_2 = annular cross-sectional area between rear buffer entrance and piston cam

A_3 = annular cross-sectional area of piston through cam

A_4 = difference between areas A_3 & A_5

A_5 = annular cross-sectional area of piston sleeve through shank

A_{S_1} = side pressure area of inside seal

A_{S_2} = side pressure area of outside seal

G_F = radial gap of front buffer at entrance

G_R = radial gap or rear buffer at entrance

P_{cr} = critical axial buckling load on end of piston

P_{pt} = actual maximum load on end of piston

I = moment of inertia of piston in bending

C = compression of fluid at latch in %

R_{av} = average outside radius of both buffers

r_{av} = average inside radius of both buffers

Fixed, Unchangeable Constants

g	$= 9.81\ m/sec^2$ ($386.088\ in/sec^2$)	acceleration of gravity
E	$= 199.95x10^9$ Pa ($29x10^6$ psi)	modulus of elasticity for steel
ν_s	= 0.287	Poisson's ratio for steel
ρ_s	$= 798.685\ kg\ sec^2/m^4$ (.000,732,994 $lb\ sec^2/in.^4$)	density of steel
ω	$= 939.5\ kg/m^3$ (.033,942 $lb/in.^3$)	specific weight of Dow Corning 200 silicon fluid at atmospheric pressure
ν_R	= .48	Poisson's ratio for Nitrile rubber
μ_R	= .50	dynamic coefficient of friction for rubber
M_R	$= 300.65\ kg\ sec^2/m$ (16.8355 $lb\ sec^2/in.$)	mass of recoiling parts
W_R	= 2948.4 kg (6500 lb)	weight of recoiling parts
$B_{(t)}$	= (see appendix A)	firing impulse at breech (variables)
N	= 12.67	tangent of slope of bulk modulus curve
β	= NP+9,1356 (NP+132,500)	bulk modulus (see appendix D)
K	= .95	flow coefficient (see appendix C)
γ	= 75°, 45°, 10°	angle of elevation of weapon
H,J,R. S&U		control functions (see page 18)
*σ max	$= 5.516x10^8$ Pa (80,000 psi)	maximum allowable tensile stress in all cylinder parts (safety factor approximately 2)

*Assuming steel used is
AISI 4130 or 4140 QQ-S-624 or equal.
Rc 36-40 ultimate tensile stress - $1.2411x10^9$ Pa (180,000 psi)
Tensile yield stress - $1.1238x10^9$ Pa (163,000 psi)

COMMENTS PERTAINING TO THE MATHEMATICAL MODELS

Several mathematical models were developed before the final one shown on the preceding pages was derived. Many computer studies were programmed and run based upon these models. Certain important facts emerged from these studies.

Professor A. P. Boresi of the University of Illinois developed a finite elements model and 26 computer runs were made with this program. The results did not solve all of the problems, since this was only a static model. What was established, however, was how thin the cylinder walls could be without being overstressed. In addition, the magnitude of wall deflection and the approximate amount of energy which the walls would be capable of absorbing were determined.

Since the problem is actually a dynamic problem, another computer program was set up with all the velocities and masses taken into account. Mr. Joe Wilson ran this program on an analog computer. A total of 27 runs were made. Since the analog computer is limited in the quantity of unknowns it can solve for, this study was also restricted in its scope. However, it did establish the run-up velocity and the run-up distance required to achieve that velocity.

The factor which will ultimately determine how well the system works, however, is not the amount of energy stored or the run-up velocity, but if the recoiling mass consistently, but just barely returns to the latch position (with all the breech energy spent). Of course, equally important is the piston force (rod pull) transmitted to the structure. The longer the run-up-distance, the smaller this force may be and the softer the recoil will be. These facts show up clearly in the analog printouts.

Finally, after several attempts, one all-inclusive mathematical model was written which was valid for all three firing conditions (normal, misfire, and cook-off) and for any possible position of the piston. The development of this model is summarized in equations 70 through 79. With this model the overwhelming amount of input and output data had to be limited so as not to obscure the most important relationships. However, a tool was now available which could be used for a trial-and-error type of optimization of the most important parameters. About 100 computer runs were made. Of these, eight were good runs which are summarized in the following paragraph. (Mr. Philip Benzkofer programmed and ran this study on a digital computer.)

RESULTS OF THE COMPUTER RUNS

Table 1 shows the data which were held constant during the 8 "good" computer runs. One of these runs is shown as appendix E.

Figure 5 is a to-scale drawing based upon the dimensions given in table 1. The drawing is merely a concept study in that no thought was given as to how the mechanism could be broken up into smaller parts for ease of machining and assembly.

Table 2 lists relevant engineering information calculated from some of the computer data.

Table 3 has pressures, stresses, and other optimized values from the computer runs.

DISCUSSION

The thought of a compressible liquid recoil system opens up the possibility of a greatly improved and simplified recoil mechanism. There would appear to be a likelihood of storing a large amount of energy in a small space, thus achieving a greatly simplified and "clean" one-principle, one-fluid design. There would be fewer tanks and fewer sub-mechanisms, fewer parts overall. Therefore, the main criterion that has been adhered to thoughout the program is simplification.

The RESULTS give a set of ideal dimensions and parameters for the CFSR mechanism which are discussed in detail in the following paragraph.

Recoil Cylinder (Fig 5)

The outside diameter of the recoil cylinder is 60.20 cm (23.7 in.). The cylinder surrounds (is coaxial with) the 33.02 cm (13-inch) diameter barrel (cannon tube). The effective length of the cylinder is 215.9 cm (85 in.). There remains a rather small space for the fluid. This small cylinder size is made possible only by allowing different parameters for the 3 different firing conditions, i.e., the cylinder still does not hold enough fluid to function properly during misfire. Recognizing how rarely a misfire occurs, this gives the designer a choice of whether or not to design for misfire. The only thing that probably would occur with the system underdesigned for misfire is that the piston would draw a vacuum which would cause cavitation and foaming. This may not be serious if it does not occur too frequently.

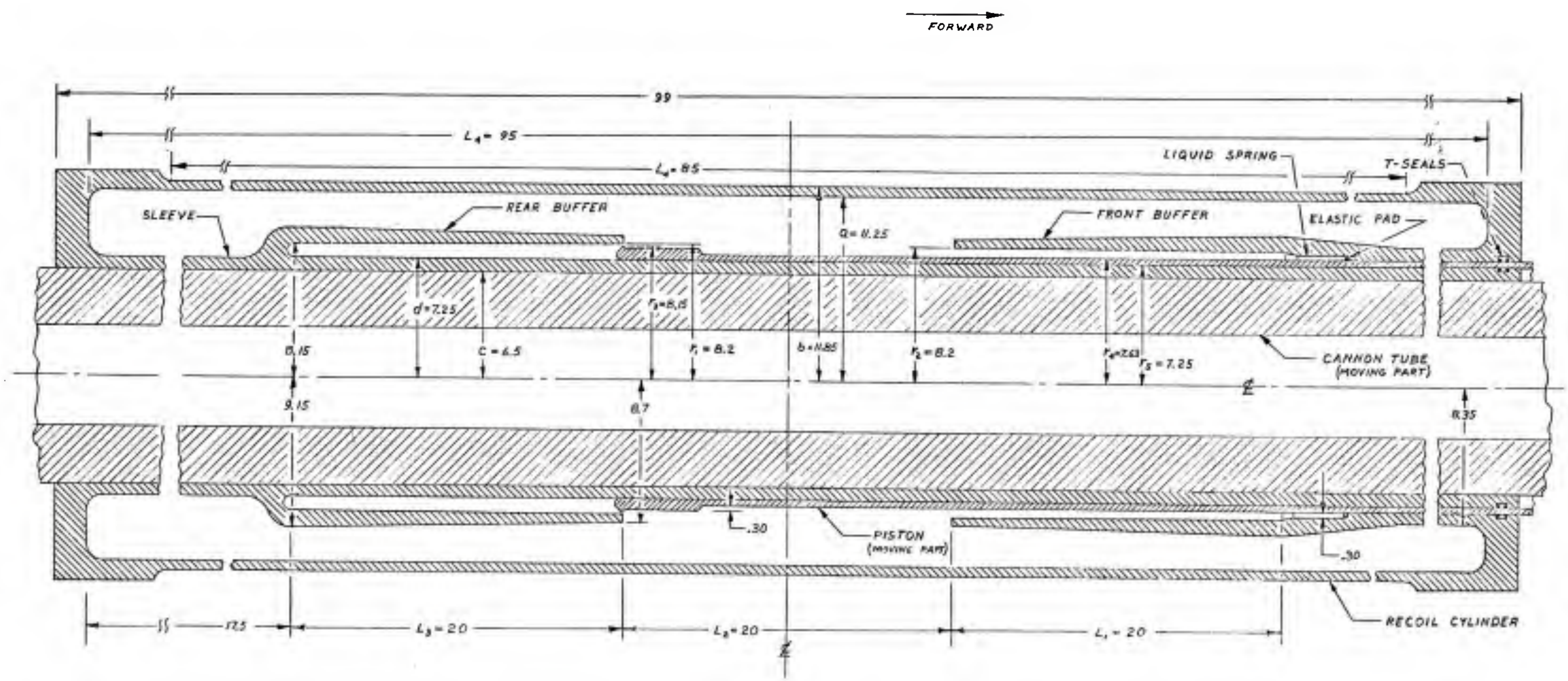


Figure 5. Preliminary CFSR concept study no. 1
(Dimensions are given in inches)

Table 1 Computer run constants

Parameter	Value mm (in.)
Run-up distance in front buffer (L_1)	508 mm (20 in.)
Run-up distance for normal firing (between buffers) (L_2)	508 mm (20 in.)
Run-up distance in rear buffer (L_3)	508 mm (20 in.)
Length of outside flexible cylinder (L_4)	2159 mm (85 in.)
Inside radius of rear buffer, at its entrance (r_1)	208.3 mm (8.20 in.)
Inside radius of front buffer at its entrance (r_2)	208.3 mm (8.20 in.)
Outside radius of piston over orifice cam (r_3)	207 mm (8.15 in.)
Outside radius of piston sleeve (r_4)	193.7 mm (7.625 in.)
Inside radius of piston sleeve (r_5)	184.2 mm (7.25 in.)
Inside radius of outside flexible cylinder (a)	285.8 mm (11.25 in.)
Outside radius of outside flexible cylinder (b)	301 mm (11.85 in.)
Inside radius of sleeve (c)	165.1 mm (6.50 in.)
Outside radius of sleeve (d)	184.2 mm (7.25 in.)
Outer wall thickness (b-a)	15.2 mm (.60 in.)
Inner wall thickness (d-c)	19.1 mm (.75 in.)
Front buffer gap (G_F)	1.3 mm (.05 in.)
Rear buffer gap (G_R)	1.3 mm (.05 in.)
Annular effective front buffer gap area (A_1)	65.2 mm^2 (2.568 $in.^2$)
Annular effective rear buffer gap area (A_2)	65.2 mm^2 (2.568 $in.^2$)

Table 1 (Cont'd)

Parameter	Value mm (in.)
Piston sleeve thickness $(r_4 - r_5)$	9.5 mm (0.375 in.)
Annular effective cross sectional piston area (A_5)	445.1 mm^2 (17.524 $in.^2$)
Moment of inertia for cross section of piston (I)	20,187 cm^4 (485 $in.^4$)
Maximum critical buckling load on end of piston (P_0)	5,203,792 kg (11,472,396 lb)
Initial pressure at latch (P_{init})	20,684.2 kPa (3000 psi)
Average outside radius of both buffers (R_{av})	232.4 mm (9.15 in.)
Average inside radius of both buffers (r_{av})	207 mm (8.15 in.)
Approximate volume of buffers, filling oil space (V_B)	34,113 cm^3 (2,081.7 $in.^3$)
Impulse energy at breech (E_{br})	597,496 Nn (5,288,287 in.-lb)

Table 2. Calculated data

Extra fluid volume in connected container (V_o)	0	.164 m³ (10,000 in.³)/ 164 litre (43.29 gal)	0	.164 m³ (10,000 in.³)/ 164 litre (43.29 gal)
Approximate volume of the two buffers (V_B)	0	0	.0339 m³ (2,081 in.³)	.0339 m³ (2,081 in.³)
Total fluid volume in recoil cylinder (V)	3186 m³ (19,543 in.³)/ 318.6 litre (84.60 gal)	.485 m³ (29,724 in.³)/ 485 litre (128.67 gal)	.2599 m³ (15,948 in.³)/ 259.9 litre (69.04 gal)	.4259 m³ (26,126 in.³)/ 425.9 litre (113.10 gal)
Total weight of fluid (W_f)	300.9 kg (663.3 lb)	457.6 kg (1,008.9 lb)	245.5 kg (541.3 lb)	402.2 kg (886.8 lb)
*The value of X calculated for the point where all pressures are zero (X_o)	1209 mm (47.6 in.)	1470.7 mm (57.9 in.)	1117.6 mm (44.0 in.)	1376.7 mm (54.2 in.)
Compression of fluid at latch in % (C)	1.7572 %	1.7624 %	1.7579 %	1.7570 %
C at smallest X	2.6464 %	2.3471 %	2.8476 %	2.4222 %

*X = distance of piston travel from its innermost position in rear buffer.

Table 3. Basic engineering values calculated from computer runs; $V_B = 0$*

Run no.		1	2	3	4	5	6	7	8
Mode of fire		H = 0 when $\dot{X} < V_e$; H = 1 when $\dot{X} \geq V_e$ Normal fire					H = 0 Misfire		H = 1 Cook-off
γ°		0	0	0	45	75	0	0	0
V_o	cm^3 ($in.^3$)	0	0	0	0	0	0	163.871 (10,000)	0
P_1 max	Pa (psi)	2.863x10^7 (4,152)	2.881x10^7 (4,179)	2.847x10^7 (4,129)	2.936x10^7 (4,258)	2.959x10^7 (4,291)	2.068x10^7 (2,999)	2.418x10^7 (3,507)	3.147x10^7 (4,564)
P_2 max	Pa (psi)	2.863x10^7 (4,152)	2.881x10^7 (4,179)	2.847x10^7 (4,129)	2.936x10^7 (4,258)	2.959x10^7 (4,291)	2.068x10^7 (2,999)	2.068x10^7 (3,000)	3.147x10^7 (4,564)
P_3 max	Pa (psi)	3.833x10^7 (5,560)	4.024x10^7 (5,837)	3.840x10^7 (5,569)	4.273x10^7 (6,197)	4.444x10^7 (6,445)	2.068x10^7 (2,999)	2.068x10^7 (3,000)	6.936x10^7 (10,060)
P min	Pa (psi)	-1.248x10^6 (- 181)	9.253x10^6 (1,342)	6.714x10^6 (974)	1.303x10^6 (189)	2.241x10^6 (325)	-5.792x10^6 (- 840)	3.034x10^5 (44)	1.682x10^7 (2,439)
σ_t	Pa (psi)	5.514x10^8 (79,977)	5.550x10^8 (80,497)	5.485x10^8 (79,546)	5.656x10^8 (82,027)	5.699x10^8 (82,654)	3.984x10^8 (57,778)	3.984x10^8 (57,781)	6.061x10^8 (87,912)
σ_a	Pa (psi)	2.614x10^8 (37,912)	2.631x10^8 (38,159)	2.600x10^8 (37,708)	2.681x10^8 (38,884)	2.702x10^8 (39,182)	1.888x10^8 (27,389)	1.889x10^8 (27,391)	2.873x10^8 (41,674)
σ_r	Pa (psi)	-2.863x10^7 (-4,152)	-2.881x10^7 (-4,179)	-2.848x10^7 (-4,130)	-2.936x10^7 (4,258)	-2.959x10^7 (-4,291)	-2.068x10^7 (-2,999)	-2.068x10^7 (3,000)	-3.147x10^7 (-4,564)
σ_e	Pa (psi)	3.552x10^8 (51,518)	3.575x10^8 (51,853)	3.533x10^8 (51,241)	3.643x10^8 (52,839)	3.670x10^8 (53,243)	2.566x10^8 (37,219)	2.566x10^8 (37,220)	3.905x10^8 (56,630)
Δa max	mm (in.)	.693 (.0273)	.696 (.0274)	.688 (.0271)	.711 (.0280)	.716 (.0282)	.501 (.0197)	.500 (.0197)	.762 (.030)
Δd max	mm (in.)	-.196 (-.0077)	-.198 (-.0078)	-.196 (-.0077)	-.201 (-.0079)	-.203 (.0080)	-.142 (-.0056)	-.142 (-.0056)	.216 (.0085)
E_{br}	Nm (in.lb)	← 597,496 (5,288,287) →							
E_f	Nm (in.lb)	8,575 (75,896)	1,140(10,092)	985.1 (8,719)	8863.9 (78,452)	7,983.7 (70,662)	67,232.5 (595,058)	—	3.394 (30,043)
E_c	Mm (in.lb)	174.7 (1,546)	306.5 (2,713)	259.2 (2,294)	39.4 (349)	137.4 (1,216)	15,688.4 (138,854)	—	887.4 (7,854)
P_{cr}	kg (lb)	← 5,203,792 (11,472,396) →							
P_{pt}	kg (lb)	70,693 (155,852)	75,751 (167,002)	70,706 (155,880)	81,987 (180,751)	86,672 (191,080)	23,833 (52,542)	23,841 (52,560)	153,476 (338,356)
X_o	cm (in.)	← 120.9 (47.6) →					← 147.1 (57.9) →		—
X_{po}	cm (in.)	111.76 (44)	—	—	—	—	124.5 (49)	—	—
Xmax	cm (in.)	114.3 (45)	88.9 (35)	99.1 (39)	110.5 (43.5)	108.7 (42.8)	149.9 (59)	152.4 (60)	—
Xmin	cm (in.)	25.4 (10)	24.1 (9.5)	25.1 (9.9)	23.1 (9.1)	22.4 (8.8)	—	—	15.1 (5.93)
V_e	cm/sec (in./sec)	640 (252)	566.4 (223)	607.1 (239)	571.5 (225)	546 (215)	624.8 (246)	678.2 (267)	—
V_1	cm/sec (in./sec)	462.3 (182)	467.4 (184)	464.8 (183)	447 (176)	444.5 (175)	—	—	482.6 (190)
V_m	cm/sec (in./sec)	—	—	—	—	—	1.85 (.73)	1.75 (.69)	—

*For definitions of symbols in left-hand column see paragraphs 8, 10, or 11 as appropriate.

Another alternative is to add .1639 m^3 (10,000 $in.^3$) of fluid in a container connected to the recoil cylinder. As shown in tables 2 and 3, this would maintain positive pressures throughout the misfire cycle. However, the diameter of the recoil cylinder cannot be increased to accommodate the extra fluid without also increasing the wall thickness, which would change wall deflection, energy absorbing qualities, total weight, and probably most of the other parameters as well.

The maximum stresses in the cylinder wall are close to the pre-set limit of 5.516×10^8 Pa (80,000 psi), which gives a static safety factor of about $2\frac{1}{2}$. The actual maximum stress is a tangential stress equal to 6.0613×10^8 Pa (87,912 psi) and is acceptable. This assumes steel such as AISI 4130 or 4140, or their equivalent, is used throughout.

It was desired to keep the recoil cylinder long and narrow. This would give a low weapon profile and a "clean" efficient design. Since a cylinder longer than 2.44 or 2.74 meters (8 or 9 feet) is very difficult to machine, the effective length was set at 2.13 to 2.44 meters (7 to 8 feet).

The cylinder is 15.2 mm (0.60 inch) thick and is intended to deflect approximately .50 mm (0.0197 inch) (piston at latch) to absorb some of the energy.

The inner cylinder (sleeve) over which the piston slides is heavier (19.1 mm (0.75 inch) thick) to minimize deflection .142 mm (0.0056 inch) at latch). If it deflects too much, it could cling to the barrel which slides inside the sleeve and prevent the mechanism from functioning properly.

At one time, a multi-cylinder recoil system was considered. This would be a system with several recoil cylinders in a cluster around the barrel. After considering all the pros and cons, however, the idea of a multi-cylinder recoil system was discarded, mainly for the sake of simplicity and reliability.

Dow Corning 200 Silicone Fluid

The volume and weight of the silicone fluid was finally reduced to .322 m^3 (85 gallons) 300.73 kg/663 pounds excluding the extra volume .1639 m^3 (10,000 in.^{3}) which, if included, would total .488 m^3 (129 gallons), 457.67 kg (1,009 pounds). The volume of fluid displaced by the buffers .0339 m^3 (2,081 in.^{3}) was not taken into account in the computer program since it was very uncertain initially what size and shape they would take. It would be advisable to design the buffers so that they occupy as little space as possible but still remain stiff. However, to compensate for the buffer volumes, which originally were assumed to be all fluid, an equivalent amount of fluid must be added to the cylinder volume. One way of doing this, would be to make the recoil cylinder 25.4 cm (10 inches) longer. This is shown in figure 5 as a 12.7 cm (5-inch) extension at each end of the 215.9 cm (85-inch) working length of the cylinder.

The silicon fluid is compressed only about 1.76% at latch during normal fire. The initial pressure at latch is 2.068 x 10^7 Pa (3,000 psi) ($P_1 = P_2 = P_3$). During cookoff, the compression reaches 2.85%. This is very low considering the compression could be 3 to 4% before the bulk modulus changes noticeably. Very high pressures in the recoil cylinder, however, would invalidate the linear relationship used in the mathematical model for the bulk modulus and make all the results erroneous.

The values used for the bulk modulus of the silicone fluid are all taken at room temperature. Since the bulk modulus is sensitive to temperature variations, this system would probably not work well in extreme climatic conditions without some modifications.

It has been suggested the effective bulk modulus be made softer or variable by incorporating a gas bag or spring-loaded expansion piston inside the recoil cylinder. The author, however, is opposed to adding anything to complicate the system unless it is absolutely necessary. (The system apparently works well in its present form.)

Energy Stored

The computer was programmed to integrate the energies stored in the cylinder walls (E_c), and in the fluid (E_f), by a method of incremental summation. The values, however, which are listed in table 3, vary considerably from run to run and appear to be totally unreliable. Some of the values are only 1 to 2% of the breech energy. The only thing which these values clearly show is that E_f is many times larger than E_c. It is not the 50-50 relationship which was assumed at the beginning of the program. It would appear that the walls could be designed to store a larger percentage of the energy.

Knowledge of the actual amount of energy which is stored in the system is not essential, however. The only criterion for the feasibility of the system is that the recoiling mass is pushed back, after run-up, by the breech impulse to just beyond the latch position so there is positive latching every time. This is accomplished with the present design.

Piston (Fig 5)

The piston is a long, thick cylinder (sleeve) with a 38.83 cm (14.5 inch) inside diameter and 9.53 mm (0.375 inch) thick walls. Its design is also the result of compromises. The ideal piston would be long and fairly thin, which would accommodate a long soft stroke with low pressures. However, with the piston too thin, its walls would crumble under the working pressures. Present wall thickness 9.53 mm (0.375 inch) is the minimum advised.

Calculations show that the critical buckling load of 5,203,792 kg (11,472,396 pounds) is far greater than the actual maximum load. The critical buckling load is questionable, however, since this is a very difficult value to determine at present (ref 3).

As a result of the piston being fairly thick, its working stroke is necessarily short. The maximum stroke is 64.26 cm (25.3 inch) for normal fire. The piston force, therefore, becomes fairly large. The maximum pressure occurring during cook-off surges to 6.936×10^7 Pa (10,060 psi) which results in a rod pull of 153,476 kg (338,356 lb).

The average maximum piston load for normal fire is 77,111 kg (170,000 lb). These high loads are the result of trying to keep the weight of the oil down, and of a fairly thick-walled piston. However, the peak loads last only a fraction of a second.

The outer G-T seal "sees" a pressure of about 3.172×10^7 Pa (4,600 psi) which is acceptable for this type of seal. (See appendix B.) The P_3, however, surges to 6.936×10^7 Pa (10,060 psi) and the inside seal "sees" some of this pressure. This peak pressure, as mentioned earlier, is of a very short duration and only reaches the insde seal through a long, tight squeeze under the piston and is consequently not considered critical.

The size and shape of the piston head is unimportant, except that it should have a sharp edge as shown in figure 5. This edge is part of the orifice and its sharpness eliminates much of the friction in the orifice, creating a more predictable flow coefficient. (See appendix C.)

Because of the relatively high initial pressures in the recoil cylinder and the relatively large effective piston area, the latch velocity is fairly high. It varied from 444.5 cm/sec (175 in./sec) to 482.6 cm/sec (190 in./sec). It appeared to be impossible to make this value any smaller without sacrificing some other elements of the design. Consequently, the latch mechanism must be capable of absorbing very large forces.

The firing or run-up velocities for normal fire varied from 546.1 cm/sec (215 in./sec) to 640 cm/sec (252 in./sec) in a run-up distance of 38.1 to 63.5 cm (15 to 25 in.). (This is at point of fire, after ignition delay or "coast" period.) There is, however, no real coast period since the pressure is always present and the velocity continues to increase. The fire control mechanism must start the firing operation at a lower velocity in anticipation of the desired firing velocity being reached. This will probably cause a problem since various ammunition has different time delays.

The run-up velocity, of course, must be adjustable for different zones of fire and different weapon elevations. Computer runs were made for 0°, 45°, and 75° elevations. The pressures, stresses, and velocities seemed to increase very little for the higher elevations and are very acceptable.

Buffers (Fig 5)

The two buffers are identical, each having 50.8 cm (20 in.) effective buffing distance. The size of the buffer gap (annular orifice) was given much attention. It was recognized that the smaller this gap was at the beginning of buffing, the more effective the buffing would be in slowing down the mass. With a small gap, however, the tolerances and machining become very critical. This concerns gaps in the range of .254 mm (0.01 in.). Consequently, a gap of 1.27 mm (0.05 in.) which appeared satisfactory, was selected. Both buffers taper down from a gap of 1.27 mm (0.05 in.) to zero in 50.8 mm (20 in.). The outside of the buffers are also tapered. This, however, is for strength and rigidity. It is realized that a "give" of .254 mm (0.01 in.) in the buffers would be too much, and would disrupt the closely programmed buffing cycle.

There is one condition, however, when the front buffer seems inadequate. This is during misfire. It appeared that no matter how long the buffer was made, or how steep the taper, the piston would slow down but never quite stop before it would hit the bottom of the buffer pocket. To eliminate this condition, there was a suggestion to incorporate a stiff helical spring outside the front buffer. A 35.56 cm (14.) diameter by 15.24 cm (6 in.) long spring, which would compress about 3.81 cm (1.5 in.) was proposed. The author again is opposed to adding any kind of extra mechanism to disrupt the otherwise simple and "clean" design. As an alternative, the use of a "liquid spring" is suggested.

The elements are already present to make a liquid spring (see fig 5). All that is required is to make a straight bore at the end of the taper in the front buffer, and to shape the piston with a "flat" cylindrical surface to fit fairly tight into the bore like a typical piston. One would thus have a liquid spring.

Another solution would be to put an elastic pad (fig 5) inside the bottom of the front buffer as a stopper for the piston. This also seems feasible considering the velocity of the piston at this point is very low about 17.8 mm/sec (0.7 in./sec). A bumper pad of this type should probably be added in any case.

Summary

In conclusion, the "undesirable" and the "desirable" features of the present, CFSR system will be repeated.

The undesirable points are:

1. Very high latch velocity.
2. Very high piston forces.
3. Piston hits bottom of front buffer.
4. Cavitation during some cycles.
5. Fairly large liquid volume and weight.

One feature which may be a disadvantage is that the recoil cylinder can be clamped only at its ends. The rest of the cylinder must be allowed to expand freely. Another feature which may be a disadvantage is the need to be able to "cock" the weapon in the field after a misfire. The piston must be pushed back to the latch position and the pressure raised to 2.068×10^7 Pa (3,000 psi). As had been pointed out in the discussion, however, it is possible to design around most of these undesirable features.

The desirable features are (1) simple and reliable design with few parts, and (2) less maintenance required on the finished product. The author's unsubstantiated opinion is that the total recoil mecanism will be lighter in weight and also less costly to manufacture than a conventional recoil mechanism.

RECOMMENDATIONS

The CFSR system appears to be a feasible and worthwhile concept to pursue further. It is recommended that a working model be built and tested based on the data given in this technical report. Some of the assumed parameters can then be verified or corrected as, for instance, the flow coefficient, the effective bulk modulus, stresses and strains in the metal parts, energy storing capability, and the actual seal friction. The mathematical model can then be corrected accordingly for reuse.

Dr. R. Yalamanchili has suggested making a CFSR mechanism with a cylindrical piston going right through the recoil cylinder. Although it is realized there would be some design problems, the author believes this is a very sound idea. This design would not have the undesirable features of the current concept.

The piston wall would be a little thicker where it enters the cylinder than where it exits, with a step in the thickness in between. The apparent advantage is in having a thick and stiff piston with a very small differential cross sectional area between the ends.

This design could have a long, soft stroke and low initial pressure. Less fluid volume (and weight) would be possible, cavitation could easily be eliminated, and there would be a much lower piston force and latch velocity.

Figure 6 shows this system as an alternate concept with approximate proportions and dimensions.

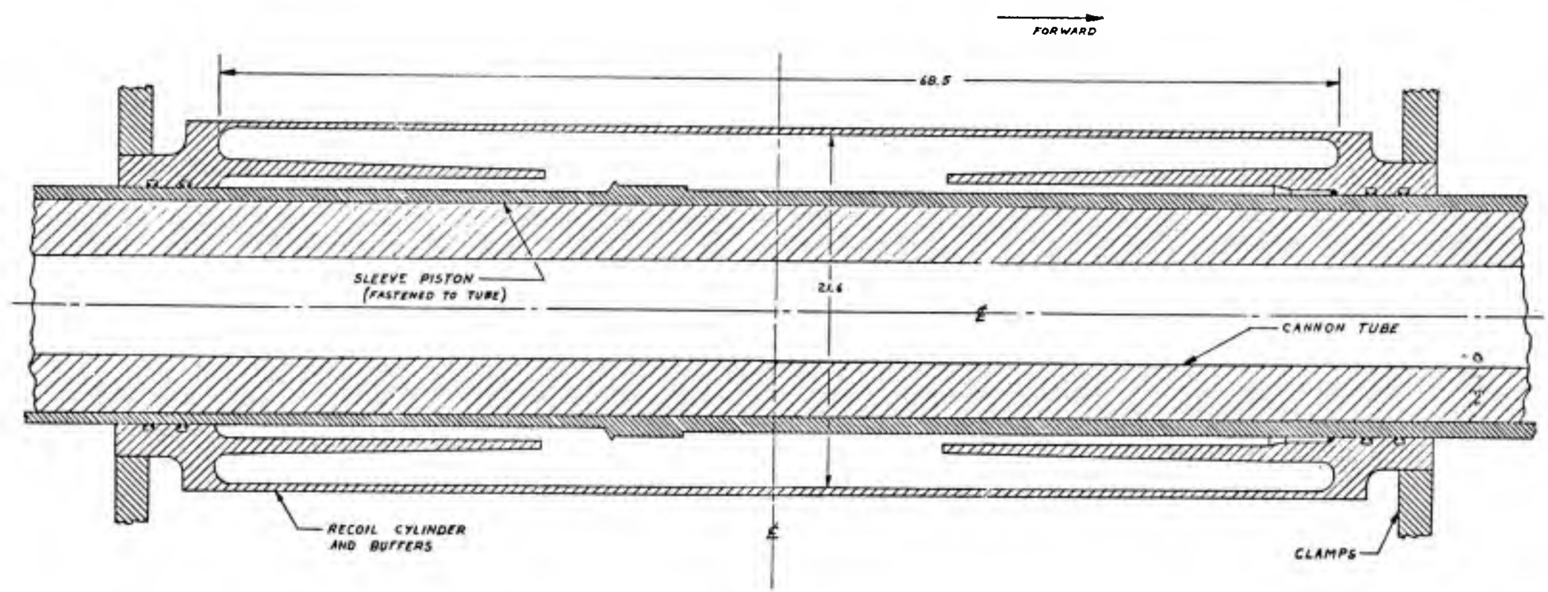


Figure 6. Preliminary CFSR concept study no. 2.
(Dimensions are given in inches)

REFERENCES

1. "155 MM Howitzer With Compressible Fluid/Soft Recoil (CFSR) Mechanism," Concept Proposal, GEN Thomas J. Rodman Laboratory, Rock Island Arsenal, Rock Island, IL, October 1975

2. Timoshenko, Stephen, Strength of Materials, Part II, Third Edition, D. Van Nostrand Co., Inc., NY, 1956

3. Flugge, Wilhelm, Stresses in Shells, Second Edition, Springer - Verlag, New York - Berlin, 1973

BIBLIOGRAPHY

1. Nerdahl, M.C. and Frantz, J.W., "Modeling Effective Fluid Compressibility in a Puteaux Recoil Mechanism," Technical Report SWERR-TR-72-34, Artillery Weapon Systems Directorate, Weapons Laboratory, US Army Weapons Command, Rock Island, IL, June 1972

2. Seely, Fred B., and Smith, James O., Advanced Mechanics of Materials, John Wiley and Sons, Inc., NY, 1959

3. Military Handbook, MIL-HDBK-5, "Strength of Metal, Aircraft Elements," Armed Forces Supply Support Center, Washington, DC, March 1961

4. Daugherty, R.L. and Ingersoll, A.C., Fluid Mechanics With Engineering Applications, McGraw-Hill Book Co., Inc., NY, 1954

5. Hofgaard, Bjorn L., Technical Note R-TN-74-002, "Stress Analysis of 105 MM Towed Howitzer XM204 Serial Number 1 & 2 - Recoil Mechanism," GEN Thomas J. Rodman Laboratory, Rock Island Arsenal Rock Island, IL, January 1974

APPENDIX A

BREECH FORCE AND BREECH ENERGY

Breech Force

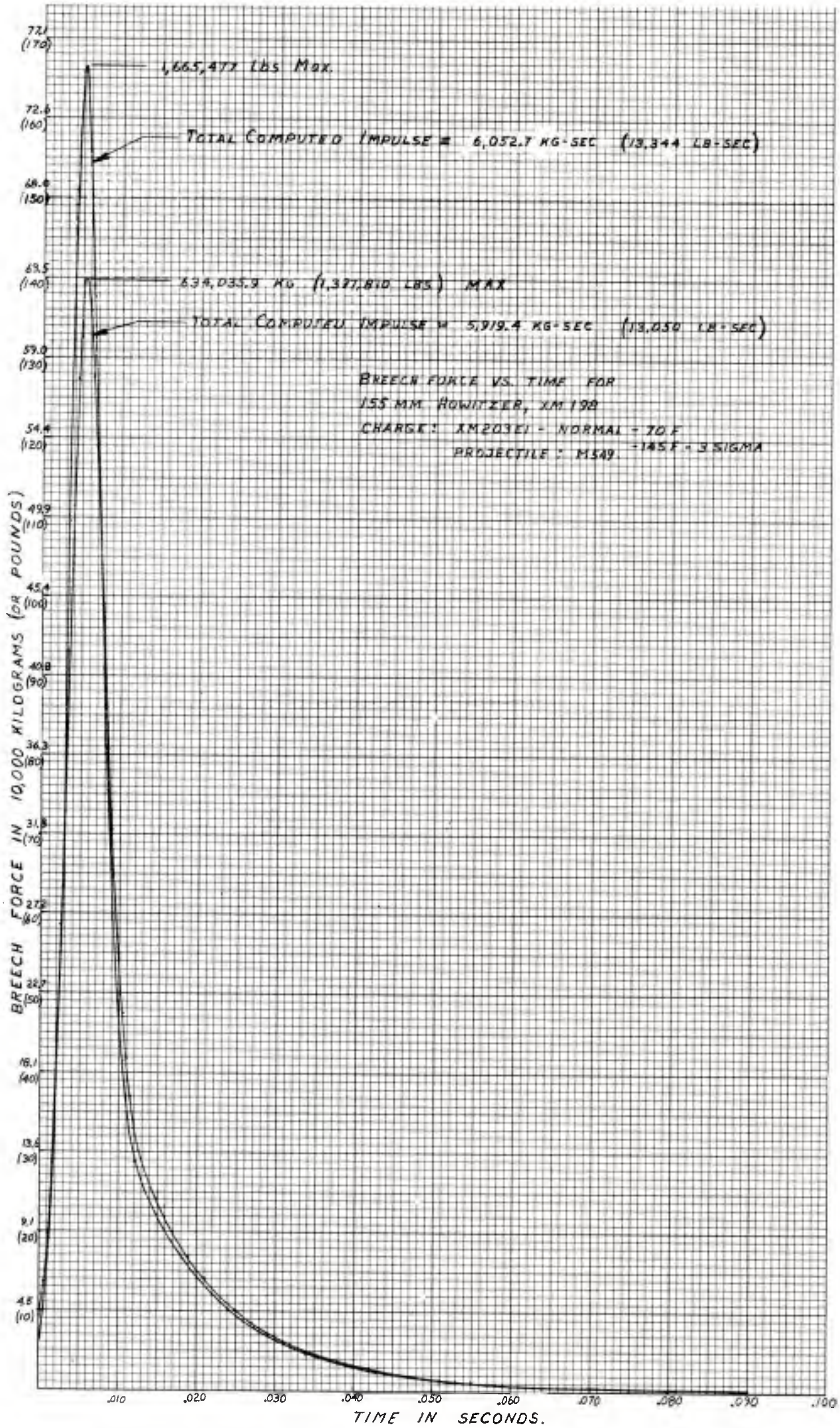
The breech force versus time curve is plotted from the M198 (155 mm) towed howitzer firing data. See page 42.

Breech Energy

The breech energy computations are given below

$$E_{br} = \frac{(I_{mp})^2 g}{2W_R} = \frac{(6052.737)^2 \; 9.81}{2(2948.35)} = 60{,}948.58 \text{ meter-kg} \qquad \text{A1}$$

$$E_{br} = \frac{(Imp)^2 g}{2W_R} = \frac{(13{,}344)^2 \; 386.088}{2(6500)} = 5{,}288{,}287 \text{ in-lb} \qquad \text{A2}$$

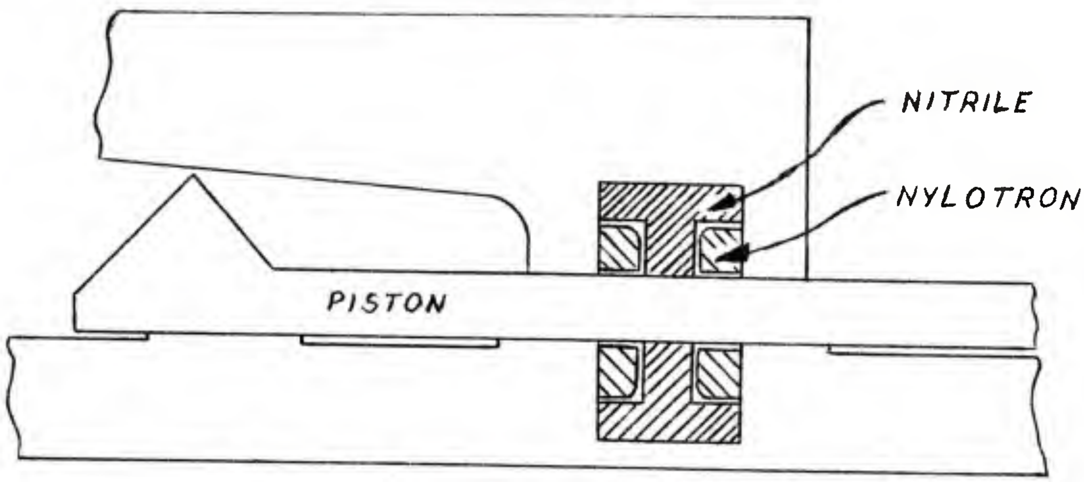


Breech force versus time

APPENDIX B

SEAL FRICTION

Two dynamic T-seals will probably be required, one outside and one inside the piston (see figure). The seals can be supplied by Greene, Tweed & Co., and are made from Nitrile or Buna-N (NBR) rubber with backup rings of nylotron.



Piston seals

An unresolved problem is that the coefficient of friction and the friction force are very uncertain for these materials in this application. The data available at this time does not permit an accurate, detailed analysis of oil pressure and seal friction. The friction formula given below should, however, be adequate for this study.

$$F = \mu_R \nu_R A_S P \tag{B-1}$$

where:

F = Axial friction force on the piston

A_S = Side area of seal backup ring plus edge of T-seal (Dimensions are taken from the Greene, tweed & Co.'s Palmetto catalog.)

μ_R = 0.50 = coefficient of friction (An approximate figure for rubber supplied by RIA Rubber Laboratory.)

ν_R = 0.48 = Poisson's ratio for rubber (An approximate figure supplied by the RIA Rubber Laboratory.)

P = Fluid pressure in psi.

Inside seal:

$$*A_{S_1} = \pi(7.25^2 - 7.00^2) = 11.1919 \text{ in}^2 \quad \text{(B-2)}$$

$$*F = 0.50(.48)11.1919P = 2.69\,P. \quad \text{(B-3)}$$

Outside seal:

$$*A_{S_2} = \pi(8.00^2 - 7.75^2) = 12.37 \text{ in}^2 \quad \text{(B-4)}$$

$$*F = 0.50(.48)12.37P = 2.97\,P. \quad \text{(B-5)}$$

This relationship, variable with pressure, was used in the mathematical model. It is the best approximation available for the seal friction at the present time.

Since the piston will be machined to slide over the inside sleeve and probably will have a fairly close sliding fit in certain areas, it is believed that the inside seal never "sees" the full peak pressure which only lasts a fraction of a second. It was therefore arbitrarily decided to use only 50% of the force on this seal, which accounts for the 0.5 factor in equation 79.

Greene, Tweed and Co., North Wales, PA can supply G-T Ring seals for pressures from zero and up to 6.895×10^7 Pa (10,000 psi) and higher. The computed CFSR pressures are all well within this range.

The final dimensions of the piston and seals are not the exact dimensions used in the friction calculations shown above and used in the mathematical model. There should not, however, be any significant change in the forces.

---

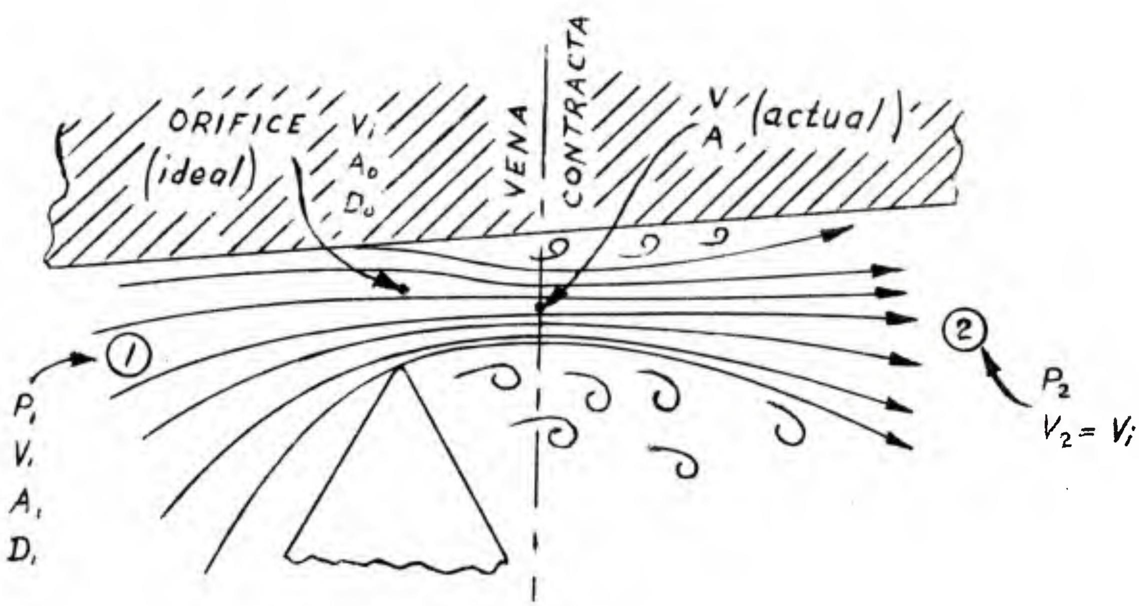
*These formulas are given in English units.

APPENDIX C

FLOW COEFFICIENT

The following information can be found in any textbook on fluid mechanics, but is included here to emphasize the number of physical conditions which the flow coefficient is dependent upon.

Looking at the flow going through an orifice (see figure), some coefficients and relationships are established.



Flow through orifice

The relationship between actual velocity (V) and ideal frictionless velocity (V_i) at "vena contracta" is determined by the coefficient of velocity (C_v), thus:

$$V = C_v V_i . \tag{C-1}$$

Vena contracta is the minimum cross section of the jet where it is contracted right outside the orifice on the down-stream side. This contraction is dependent on friction and shape of the orifice and the viscosity of the fluid.

The ratio of the cross-sectional area of a jet (A) at vena contracta to the area at the orifice (A_o) is called the coefficient of contraction (C_c). This relationship can be expressed as follows:

$$A = C_c A_o \ . \tag{C-2}$$

The ratio of the actual rate of discharge (Q) to the ideal rate of discharge (Q_i), if there were no friction and no contraction, may be defined as the coefficient of discharge (C_d).

Thus:

$$Q = C_d Q_i \tag{C-3}$$

By observing that $Q = AV$ and $Q_i = A_o V_i$, it is seen that:

$$C_d = C_c C_v \ . \tag{C-4}$$

Writing the Bernoulli's equation thru the orifice in the buffer, it

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} = \frac{P_2}{\omega} + \frac{V_2^2}{2g} \tag{C-5}$$

(See figure.)

Rearranging this equation to get the flow velocity outside the orifice ($V_2 = V_i$), it becomes

$$V_2 = \sqrt{\frac{2g}{\omega}(P_1 - P_2) + V_1^2} \tag{C-6}$$

and the actual jet velocity is

$$V = C_V \sqrt{\frac{2g}{\omega}(P_1 - P_2) + V_1^2} \ . \tag{C-7}$$

By applying the continuity equation

$$V_1 A_1 = AV \tag{C-8}$$

$$V_1 = AV/A \tag{C-9}$$

$$V_1 = C_c A_0 \; V/A \tag{C-10}$$

$$V_1 = C_c V \; (D_0/D_1)^{\circ} \tag{C-11}$$

and substituting this V_1 value into the Bernoulli equation, it becomes

$$V = \frac{C_v}{\sqrt{1 - C_d{}^2 (D_0 \;/\; D_1)^4}} \sqrt{\frac{2g}{\omega} \; (P_1 - P_2)} \; . \tag{C-12}$$

Since

$$Q = C_c A_o V \; , \tag{C-13}$$

$$Q = \frac{C_d A_0}{\sqrt{1 - C_d{}^2 \; (D_0/D_1)^4}} \sqrt{\frac{2g}{\omega} \; (P_1 - P_2)} \; . \tag{C-14}$$

Now to simplify this equation,

$$\frac{C_d}{\sqrt{1 - C_d{}^2 \, (D_0/D_1)^4}} = K \; . \tag{C-15}$$

K is called the flow coefficient, and the final equation becomes

$$Q = KA_0 \sqrt{\frac{2g}{\omega} \; (P_1 - P_2)} \tag{C-16}$$

This is the equation which is used in the mathematical model.

Since there is a variable orifice--D_o, D_1, and A_o vary-- K is not a constant. In addition, C_d, C_v, and C_c, which are dependent on orifice shape and friction or drag and viscosity, vary. Viscosity of the fluid is dependent on pressure and temperature. It must also be remembered that the specific weight of the fluid ω varies with pressure and temperature.

Unfortunately, there are no reliable flow coefficients available for this fluid. It was assumed, however, that there is an average constant coefficient for this application which would apply for the given conditions and boundaries, accounting for all the variables including ω. The very best estimate for such a value is,

$$K = 0.95 \tag{C-17}$$

APPENDIX D

BULK MODULUS

Dow Corning 200 (10 cs), a silicon fluid, is used as the working fluid in the recoil mechanism. This liquid has good compressibility and stability and a relatively flat viscosity curve.

However, many of its physical properties are not very well known. There are no precise data available either for the absolute bulk modulus, or for the effective bulk modulus which includes the container--in this case the recoil cylinder. The bulk modulus (β), an essential parameter for the solution of this recoil problem, varies with pressure and temperature over a wide range.

The bulk modulus is defined by the following differential equation:

$$\beta = - V_i \frac{dP}{dv} , \qquad \text{(D-1)}$$

where

P = Fluid pressure

V_i = Initial fluid volume

V = Fluid volume at time (t).

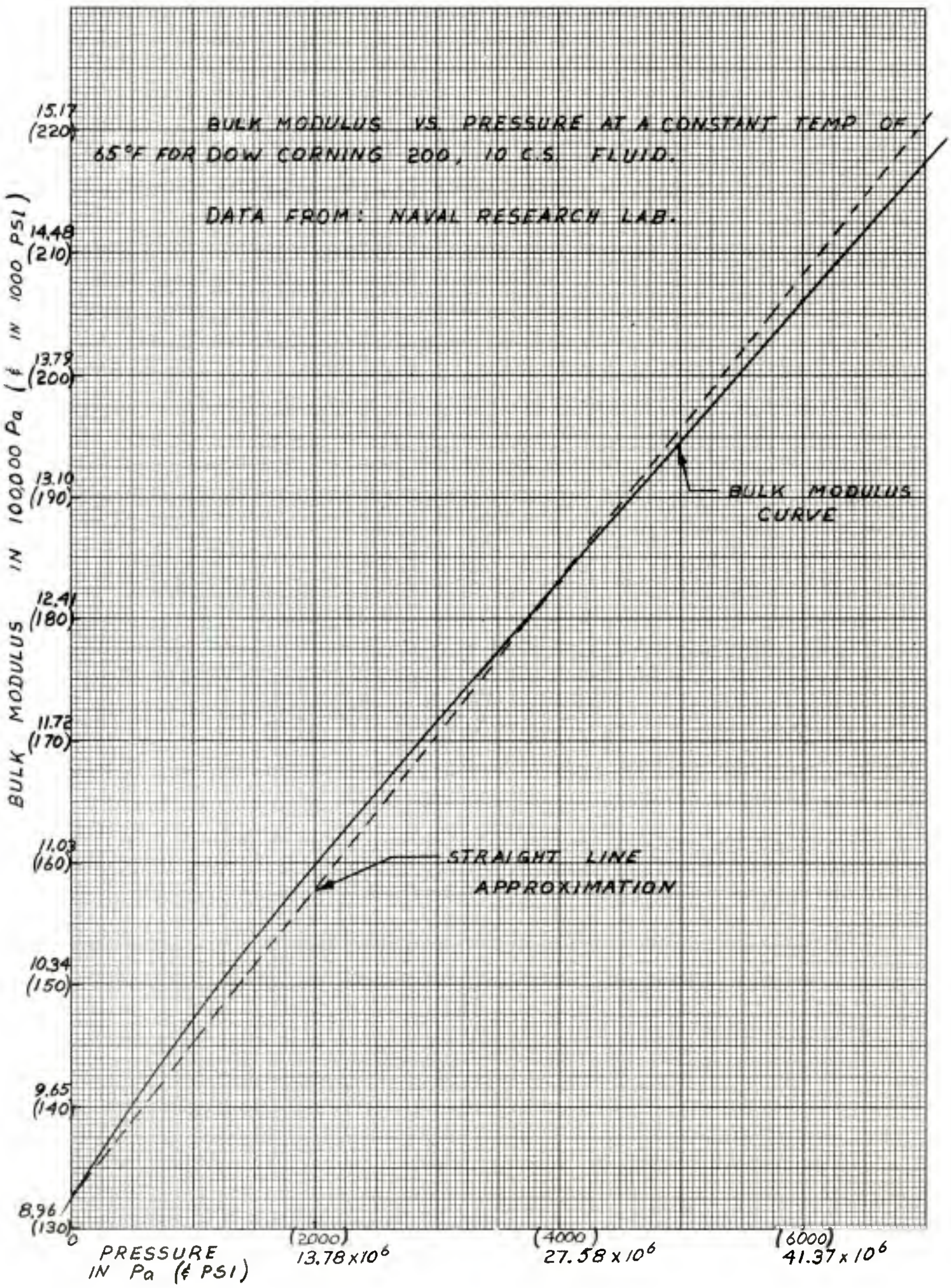
The compressibility (k) of the fluid is defined as

$$k = \frac{1}{\beta} , \qquad \text{(D-2)}$$

A few values of bulk modulus for four different pressures, covering approximately half of the pressure range of the recoil mechanism. were published by the Naval Research Laboratory. Since pressures in a recoil mechanism very greatly during a cycle, and a temperatures vary only a small amount, a curve was plotted for room temperature conditions only (65°F), using the four points available. This curve proved to be practically a straight sloping line, so a straight line was used for the needed β versus P relationship (see figure). The tangent to this curve is 12.67. Thus, the following relationship was used in the mathematical model:

$$\beta = 12.67\ P + 9.136 \times 10^8$$

$$(\beta = 12.67\ P + 132{,}500) \ . \qquad \text{(D-3)}$$



Bulk modulus versus pressure

APPENDIX E

COMPUTER PRINTOUTS
(TOTAL PROGRAM)

```
*DARCOM MIDWEST SECC* RM9.PR1  A..START JOB 7994...2.03.21 PM 15 JUN 77.2T03.K173.KW3PDB70.BENZKOFER          *DARCOM MIDWEST SECC*
```

```
*DARCOM MIDWEST SECC* RM9.PR1  A..START JOB 7994...2.03.21 PM 15 JUN 77.2T03.K173.KW3PDB70.BENZKOFER          *DARCOM MIDWEST SECC*
*DARCOM MIDWEST SECC* RM9.PR1  A..START JOB 7994...2.03.21 PM 15 JUN 77.2T03.K173.KW3PDB70.BENZKOFER          *DARCOM MIDWEST SECC*
```

```
                                         H A S P    J O B    L O G

$13.51.19 JOB 7994 - KW3PDB70 - RDR ON 13.22.18 - BEGINNING EXEC - INIT 4 - CLASS A
 13.51.21 JOB 7994 IEF403I KW3PDB70 STARTED    TIME=13.51.21
$13.52.20 JOB 7994 ESTIMATED TIME EXCEEDED
 13.57.46 JOB 7994 IEF404I KW3PDB70 ENDED      TIME=13.57.46
N13.57.47 JOB 7994 END EXECUTION.


---- HASP-II JOB STATISTICS ----


      426 CARDS READ


    1,214 SYSOUT PRINT RECORDS


        0 SYSOUT PUNCH RECORDS


     6.49 MINUTES EXECUTION TIME
```

```
//KW3PDB70 JOB (2T03,K173,1,3,9999,,,,65),'BENZKOFER'                        JOB 7994
// EXEC FORTGCLG,REGION=150K
XXDEFAULTS PROC SYSOUT=A                                                     00000100
XXFORT     EXEC PGM=IEYFORT,REGION=106K,DPRTY=(3,3)                          00000200
XXSYSPRINT DD   SYSOUT=&SYSOUT                                               00000300
IEF653I SUBSTITUTION JCL - SYSOUT=A
XXSYSLIN   DD   DSN=&&OBJECT,UNIT=ITEL,SPACE=(CYL,(1,1)),                    00000400
XX              DCB=BLKSIZE=800,DISP=(,PASS)                                 00000500
//FORT.SYSIN DD *
IEF236I ALLOC. FOR KW3PDB70 FORT
IEF237I 0C2   ALLOCATED TO SYSPRINT
IEF237I 114   ALLOCATED TO SYSLIN
IEF237I 090   ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS77165.T131819.RV000.KW3PDB70.OBJECT        PASSED
IEF285I   VOL SER NOS= IFSEOS.
IEF373I STEP /FORT    / START 77166.1351
IEF374I STEP /FORT    / STOP  77166.1351 CPU   0MIN 16.82SEC MAIN 100K CC=   0

*STEP FORT    **JOB KW3PDB70*******************************************************************
*RESOURCE- CORE(K)  DISK(IO)  TAPE(IO)--UNITS(U)    IN-HASP(IO)-OUT OTHER(IO)   CPU TIME(C) STEP TIME(T)  *
*USAGE-       150        53         0         0     404        553          0   00:00:16.82  00:00:25.87  *
*******************************************************************************************************

XXLKED     EXEC PGM=IEWLF880,PARM='LIST,LET,XREF',REGION=100K,               00000600
XX              COND=(4,LT,FORT),DPRTY=(3,3)                                 00000700
XXSYSPRINT DD   SYSOUT=&SYSOUT                                               00000800
IEF653I SUBSTITUTION JCL - SYSOUT=A
XXSYSLIB   DD   DSN=NONQ.FORTLIB,DISP=SHR                                    00000900
XXSYSLIN   DD   DSN=&&OBJECT,DISP=(OLD,DELETE)                               00001000
XX         DD   DDNAME=SYSIN                                                 00001100
XXSYSUT1   DD   UNIT=ITEL,SPACE=(CYL,(1,1))                                  00001200
XXSYSLMOD  DD   DSN=&&LOAD(MAIN),UNIT=ITEL,SPACE=(CYL,(1,3,1)),              00001300
XX              DISP=(,PASS)                                                 00001400
IEF236I ALLOC. FOR KW3PDB70 LKED
IEF237I 0C2   ALLOCATED TO SYSPRINT
IEF237I 115   ALLOCATED TO SYSLIB
IEF237I 114   ALLOCATED TO SYSLIN
IEF237I 114   ALLOCATED TO SYSUT1
IEF237I 114   ALLOCATED TO SYSLMOD
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NOS= IFSEPP.
IEF285I   SYS77165.T131819.RV000.KW3PDB70.OBJECT        DELETED
IEF285I   VOL SER NOS= IFSEOS.
IEF285I   SYS77165.T131819.RV000.KW3PDB70.R0004992      DELETED
IEF285I   VOL SER NOS= IFSEOS.
IEF285I   SYS77165.T131819.RV000.KW3PDB70.LOAD          PASSED
IEF285I   VOL SER NOS= IFSEOS.
IEF373I STEP /LKED    / START 77166.1351
IEF374I STEP /LKED  . / STOP  77166.1352 CPU   0MIN 02.24SEC MAIN  98K CC=   0

*STEP LKED    **JOB KW3PDB70*******************************************************************
*RESOURCE- CORE(K)  DISK(IO)  TAPE(IO)--UNITS(U)    IN-HASP(IO)-OUT OTHER(IO)   CPU TIME(C) STEP TIME(T)  *
*USAGE-       150       337         0         0       0        163          0   00:00:02.24  00:00:15.57  *
*******************************************************************************************************
```

```
XXGO        EXEC PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED)),         00001500
XX               DPRTY=(3,3)                                                00001600
XXFT05F001 DD   DDNAME=SYSIN                                                00001700
XXFT06F001 DD   SYSOUT=&SYSOUT                                              00001800
IEF653I SUBSTITUTION JCL - SYSOUT=A
XXFT07F001 DD   SYSOUT=B                                                    00001900
//GO.SYSIN DD *
//

IEF236I ALLOC. FOR KW3PDB70 GO
IEF237I 114    ALLOCATED TO PGM=*.DD
IEF237I 090    ALLOCATED TO FT05F001
IEF237I 0C2    ALLOCATED TO FT06F001
IEF237I 1A2    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS77165.T131819.RV000.KW3PDB70.LOAD         PASSED
IEF285I   VOL SER NOS= IFSEOS.
IEF373I STEP /GO      / START 77166.1352
IEF374I STEP /GO      / STOP  77166.1357 CPU   3MIN 19.59SEC MAIN  48K CC=   0

*STEP GO      **JOB KW3PDB70*****************************************************************
*RESOURCE- CORE(K)  DISK(IO)  TAPE(IO)--UNITS(U)     IN-HASP(IO)-OUT OTHER(IO)   CPU TIME(C) STEP TIME(T)  *
*USAGE-       150         0          0          0         20       409         0   00:03:19.59  00:05:34.17  *
*****************************************************************************************************

IEF285I   SYS77165.T131819.RV000.KW3PDB70.LOAD         DELETED
IEF285I   VOL SER NOS= IFSEOS.
IEF375I  JOB /KW3PDB70/ START 77166.1351
IEF376I  JOB /KW3PDB70/ STOP  77166.1357 CPU   3MIN 38.65SEC

*JOB KW3PDB70**2T03**K173**BENZKOFER*****************************************************************
*UNITS- CORE(K*T)   DISK(IO)   TAPE(IO)  TAPE(U*T)  HASPI(IO)  HASPO(IO)  OTHER(IO)    CPU(C)      TOTAL  *
*COSTS-     $1.97      $0.12      $0.00      $0.00      $0.00      $0.00      $0.00    $13.36     $15.45  *
*****************************************************************************************************
```

```
      REAL L1,L2,L3,L4,MR,N,NU,I,J
      EXTERNAL F7,F8,F9
      DIMENSION TIME(81),BFORCE(81)
      COMMON/BLK1/H,HH
      COMMON/BLK2/DI,F,HI,I,J,R,S,TI,U
      COMMON/BLK3/IP,PB1,PB2,PB3
      COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
      COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
      NAMELIST/NAM/R1,R2,R3,R4,R5,A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,
     1E,N,NU,V0,WR,GAMMA
      NAMELIST/NAM1/TIME,BFORCE
      READ(5,NAM)
      WRITE(6,NAM)
      READ(5,NAM1)
      WRITE(6,NAM1)
      MR=WR/G
      DI=0.
      U=0.
      F=0.
      R=1.
      HI=0.
      J=0.
      TI=-1.
      S=-1.
      I=0.
      IMISFR=0
      INORM=1
      IRBUFF=0
      VE=240.
      ICHECK=0
      IPRESS=0
      T=0.
      PB1=0.
      PB2=0.
      PB3=0.
      P2=3000.
      P1=P2
      P3=3000.
C     L4=L1+L2+L3
      L4=85.
      DELA=3.1416*L4*P2*A/(3.1416*L4*E/((B**2+(1.-NU)*A**2)/(B**2-
     1A**2)+NU))
      DELD=-3.1416*L4*P2*D/(3.1416*L4*E/((D**2*(1.-NU)+C**2)/(D**2-
     1C**2)-NU))
      DELAD=0.
      DELDD=0.
      A1=3.1416*(R2**2-R3**2)
      A2=3.1416*(R1**2-R3**2)
      A3=3.1416*(R3**2-R5**2)
      A4=3.1416*(R3**2-R4**2)
      A5=3.1416*(R4**2-R5**2)
      X=L3
      XD=0.
```

```
      H=.00005
      HH=H/2.
      SUM=L2+L3
      IP=1
      KOUNT=0
      EF=0.
      EC=0.
      IF(INORM.EQ.1) GO TO 3
      IF(INORM.EQ.0.AND.IMISFR.EQ.1) GO TO 12
    1 CALL LINEAR(T,TIME,BFORCE,PB1)
      T=T+HH
      CALL LINEAR(T,TIME,BFORCE,PB2)
      T=T+HH
      CALL LINEAR(T,TIME,BFORCE,PB3)
      IP=1
    3 CALL KUTTA(X,XD,P3,P2)
      XDD=F1(X,XD,P3,P2)
      CALL KUTTA2(DELA,DELD,DELAD,DELDD,P2)
      DELADD=F5(DELA,DELAD,P2)
      DELDDD=F6(DELD,DELDD,P2)
      CALL KUTTA1(X,XD,P2,P2,P3,DELA,DELAD,DELD,DELDD)
      P1D=F2(X,XD,P1,P2)
      P2D=F3(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
      P3D=F4(X,XD,P2,P3)
      IF(X.LT.SUM) GO TO 13
      DI=1.
      U=1.
      F=1.
      GO TO 13
   12 T=T+H
      CALL KUTTA(X,XD,P3,P1)
      XDD=F1(X,XD,P3,P1)
      IF(X.LT.SUM) GO TO 16
      DI=1.
      U=1.
      F=1.
   16 CALL KUTTA2(DELA,DELD,DELAD,DELDD,P2)
      DELADD=F5(DELA,DELAD,P2)
      DELDDD=F6(DELD,DELDD,P2)
      CALL KUTTA1(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
      P1D=F2(X,XD,P1,P2)
      P2D=F3(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
      P3D=F4(X,XD,P2,P3)
      IF(X.GT.SUM) P3=P2
      IF(X.GT.SUM) GO TO 14
      P1=P2
      P3=P2
      DI=0.
      U=0.
      F=0.
      GO TO 14
   13 IF(IRBUFF.EQ.1) GO TO 11
      IF(X.GT.SUM) GO TO 19
```

```
0103            DI=0.
0104            U=0.
0105            F=0.
0106            P1=P2
0107            P3=P2
0108         11 P1=P2
0109            GO TO 14
0110         19 P3=P2
0111         14 SIGT=(B**2+A**2)/(B**2-A**2)*P2
0112            SIGAX=A**2*P2/(B**2-A**2)
0113            SIGR=-P2
0114            SIGE=.5*SQRT((SIGT-SIGR)**2+(SIGR-SIGAX)**2+(SIGAX-SIGT)**2)
0115            V1=3.1416*(A**2-D**2)*L4+V0
0116            KOUNT=KOUNT+1
0117            IF(P2.LE.0.) GO TO 20
0118            V=3.1416*((A+DELA)**2-(D+DELD)**2)*L4+A5*(L4-X)
0119            EF=EF-F9(V,P2,P2D,N)*H
0120            EC=EC+2.*3.1416*L4*(F7(A,DELA,DELAD,P2)+F8(D,DELD,DELDD,P2))*H
0121         20 IF(KOUNT.LT.40) GO TO 7
0122            KOUNT=0
0123            PRINT 5,T,X,XD,XDD,P1,P1D,P2,P2D,P3,P3D
0124          5 FORMAT(2X,'T=',F6.4,1X,'X=',F6.3,1X,'XD=',F9.2,1X,'XDD=',F9.1,1X,
             1'P1=',F9.2,1X,'P1D=',F10.1,1X,'P2=',F9.2,1X,'P2D=',F10.1,1X,
             2'P3=',F9.2,1X,'P3D=',F9.1)
0125            PRINT 2,DELA,DELAD,DELD,DELDD,SIGT,SIGAX,SIGR,SIGE
0126          2 FORMAT(2X,'DELA=',F7.4,1X,'DELAD=',F7.4,1X,'DELD=',F7.4,1X,
             1'DELDD=',F7.4,1X,'SIGT=',F10.1,1X,'SIGAX=',F10.1,1X,
             2'SIGR=',F10.1,1X,'SIGE=',F10.1)
        C       PRINT 2,DELA,DELAD,DELD,DELDD,SIGT,SIGAX,SIGR,SIGE
        C     2 FORMAT(2X,'DELA=',F7.4,1X,'DELAD=',F7.4,1X,'DELD=',F7.4,1X,
        C    1'DELDD=',F7.4,1X,'SIGT=',F10.1,1X,'SIGAX=',F10.1,1X,
        C    2'SIGR=',F10.1,1X,'SIGE=',F10.1)
        C       PRINT 2,DELA,DELD,SIGT,SIGAX,SIGR,SIGE,EC,EF
        C     2 FORMAT(2X,'DELA=',F7.4,1X,'DELD=',F7.4,1X,
        C    1'SIGT=',F10.1,1X,'SIGAX=',F10.1,1X,
        C    2'SIGR=',F10.1,1X,'SIGE=',F10.1,1X,'EC=',F15.1,1X,'EF=',F15.1)
0127          7 IF(INORM.EQ.0.AND.IMISFR.EQ.0) GO TO 10
0128            IF(INORM.EQ.0.AND.IMISFR.EQ.1) GO TO 15
0129            IF(ICHECK.GE.1) GO TO 4
0130            IF(XDD.LE.0..OR.XD.GE.VE) GO TO 4
0131            T=T+H
0132            GO TO 3
0133          4 ICHECK=ICHECK+1
0134            IF(ICHECK.EQ.1) TT=0.
0135            CALL LINEAR(TT,TIME,BFORCE,PB1)
0136            TT=TT+HH
0137            CALL LINEAR(TT,TIME,BFORCE,PB2)
0138            TT=TT+HH
0139            CALL LINEAR(TT,TIME,BFORCE,PB3)
0140            IP=1
0141            T=T+H
0142            HI=1.
0143            IF(XD.GE.0.) GO TO 8
```

```
      S=1.
      GO TO 9
    8 S=-1.
      TI=-1.
    9 IF(X.GT.L3.AND.IRBUFF.EQ.0) GO TO 3
      I=-1.
      J=1.
      R=0.
      TI=1.
      IRBUFF=1
      IF(XD.GT.0..AND.X.GT.L3) GO TO 6
      GO TO 3
   10 IF(XD.LT.0..AND.IPRESS.EQ.1.AND.X.LT.L3) GO TO 1
      IF(XD.LT.0..AND.IPRESS.EQ.1.AND.X.GE.L3) GO TO 18
      IF(XD.LT.0..AND.IPRESS.EQ.0.AND.X.GT.L3) GO TO 17
      IF(XD.GT.0..AND.IPRESS.EQ.0.AND.X.GE.L3) GO TO 18
      IF(XD.GT.0..AND.IPRESS.EQ.1.AND.X.LT.L3) GO TO 1
      IF(XD.GT.0..AND.IPRESS.EQ.1.AND.X.GE.L3) GO TO 6
   17 IPRESS=1
      GO TO 1
   18 X=L3
      XD=0.
      GO TO 1
   15 IF(XD.GT.0.) GO TO 12
    6 PRINT 21,EC,EF
   21 FORMAT(5X,'EC=',F30.5,5X,'EF=',F30.5)
      CALL EXIT
      END
```



```
*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
*OPTIONS IN EFFECT*  NAME = MAIN     , LINECNT =       55
*STATISTICS*    SOURCE STATEMENTS =       171,PROGRAM SIZE =     5500
*STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                AF                DATE = 77166          13/51/23          PAGE 0001

 0001              FUNCTION AF(X)
 0002              REAL L1,L2,L3,L4,MR,N,NU,I,J
 0003              COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
 0004              COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
 0005              GF=R2-R3
 0006              AF=A1+3.1416*GF**2*(L2+L3)**2/L1**2+2.*3.1416*GF*R2*(L2+L3)/L1-
                  1(2.*3.1416*GF**2*(L2+L3)/L1**2+2.*3.1416*GF*R2/L1)*X+
                  23.1416*GF**2*X**2/L1**2
 0007              RETURN
 0008              END
```

```
FORTRAN IV G LEVEL  21                AF                DATE = 77166          13/51/23          PAGE 0002

  *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = AF       , LINECNT =       55
  *STATISTICS*    SOURCE STATEMENTS =        8,PROGRAM SIZE =      484
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                AR                DATE = 77166          13/51/23              PAGE 0001

                   FUNCTION AR(X)
                   REAL L1,L2,L3,L4,MR,N,NU,I,J
                   COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
                   COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
                   GR=R1-R3
                   AR=2.*3.1416*GR*R3*X/L3+3.1416*GR**2*X**2/L3**2
                   RETURN
                   END
```

```
FORTRAN IV G LEVEL  21                AR                DATE = 77166          13/51/23              PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = AR       , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        8,PROGRAM SIZE =      380
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21              QF              DATE = 77166          13/51/23              PAGE 0001

                   FUNCTION QF(P1,P2,X)
                   REAL L1,L2,L3,L4,MR,N,NU,I,J
                   COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
                   QF=AF(X)*CD*SQRT(2.*G*ABS(P1-P2)/RHOF)*SGN(P1-P2)
                   RETURN
                   END
```

```
FORTRAN IV G LEVEL  21              QF              DATE = 77166          13/51/23              PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = QF       , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        6,PROGRAM SIZE =      478
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                 QR                DATE = 77166         13/51/23            PAGE 0001

              FUNCTION QR(P2,P3,X)
              REAL L1,L2,L3,L4,MR,N,NU,I,J
              COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
              QR=AR(X)*CD*SQRT(2.*G*ABS(P3-P2)/RHOF)*SGN(P3-P2)
              RETURN
              END
```

```
FORTRAN IV G LEVEL  21                 QR                DATE = 77166         13/51/23            PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = QR       , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        6,PROGRAM SIZE =       478
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                  F1                  DATE = 77166          13/51/23                PAGE 0001

 0001              FUNCTION F1(X,XD,P3,P1)
 0002              REAL L1,L2,L3,L4,MR,N,NU,I,J
 0003              COMMON/BLK2/DI,F,HI,I,J,R,S,TI,U
 0004              COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
 0005              COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
 0006              IF(XD.GT.0.) S=-1.
 0007              IF(XD.LE.0.) S=1.
 0008              F1=1./MR*(S*(2.69*.5*P3+2.97*P1)+P3*A3-P1*A4-HI*PBF(XXX)-
                  1MR*G*SIN(GAMMA))
 0009              RETURN
 0010              END
```

```
FORTRAN IV G LEVEL  21                  F1                  DATE = 77166          13/51/23                PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = F1      , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =       10,PROGRAM SIZE =      618
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                 F2                  DATE = 77166           13/51/23              PAGE 0001

          FUNCTION F2(X,XD,P1,P2)
          REAL L1,L2,L3,L4,MR,N,NU,I,J
          COMMON/BLK2/DI,F,HI,I,J,R,S,TI,U
          COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
          COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
          F2=U*(N*P1+132500.)*(A4*XD-QF(P1,P2,X))/((A4+AF(X))*(L1+L2+L3-X))
          RETURN
          END
```

```
FORTRAN IV G LEVEL  21                 F2                  DATE = 77166           13/51/23              PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = F2       , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =          8,PROGRAM SIZE =       520
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
0001      FUNCTION F3(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
0002      REAL L1,L2,L3,L4,MR,N,NU,I,J
0003      COMMON/BLK2/DI,F,HI,I,J,R,S,TI,U
0004      COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
0005      COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
0006      BULK=-(N*P2+132500.)
0007      IF(X.GE.L3) R=1.
0008      [illegible]
0009      F3=BULK*(1.*(+2.*3.1416*L4*((A+DELA)*DELAD-(D+DELD)*DELDD)+R*A5*
         1XD)+U*(A4*XD-QF(P1,P2,X))-J*(A4*XD+QR(P2,P3,X)))/(3.1416*L4*
         2((A+DELA)**2-(D+DELD)**2)+V0+A5*(X-(L1+L2+L3))-J*(A3+AR(X))*X+
         3U*(A4+AF(X))*(X-(L1+L2+L3)))
0010      RETURN
0011      END
```



```
*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
*OPTIONS IN EFFECT*  NAME = F3     , LINECNT =      55
*STATISTICS*    SOURCE STATEMENTS =       11,PROGRAM SIZE =       970
*STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                F4                DATE = 77166          13/51/23               PAGE 0001

                  FUNCTION F4(X,XD,P2,P3)
                  REAL L1,L2,L3,L4,MR,N,NU,I,J
                  COMMON/BLK2/DI,F,HI,I,J,R,S,TI,U
                  COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
                  COMMON/BLK5/A1,A2,A3,A4,A5,R1,R2,R3,R4,R5
                  BULK=N*P3+132500.
                  F4=-J*BULK*(A3*XD+QR(P2,P3,X))/((A3+AR(X))*X)
                  RETURN
                  END
```

```
FORTRAN IV G LEVEL  21                F4                DATE = 77166          13/51/23               PAGE 0002

  *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = F4        , LINECNT =       55
  *STATISTICS*    SOURCE STATEMENTS =        9,PROGRAM SIZE =      514
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                  F5                  DATE = 77166          13/51/23              PAGE 0001

 0001               FUNCTION F5(DELA,DELAD,P2)
 0002               REAL L1,L2,L3,L4,MR,N,NU,I,J
 0003               COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
 0004               F5=1./(RHOS*(B**2-A**2))*(2.*A*P2-2.*E*DELA/((B**2
                   1+(1.-NU)*A**2)/(B**2-A**2)+NU))
 0005               RETURN
 0006               END
```

```
FORTRAN IV G LEVEL  21                  F5                  DATE = 77166          13/51/23              PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = F5       , LINECNT =        55
 *STATISTICS*    SOURCE STATEMENTS =          6,PROGRAM SIZE =       472
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                  F6                DATE = 77166          13/51/23            PAGE 0001

 0001                FUNCTION F6(DELD,DELDD,P2)
 0002                REAL L1,L2,L3,L4,MR,N,NU,I,J
 0003                COMMON/BLK4/A,B,C,D,G,CD,RHOF,RHOS,L1,L2,L3,L4,E,N,NU,V0,MR,GAMMA
 0004                F6=1./(RHOS*(D**2-C**2))*(-2.*D*P2-2.*E*DELD/((D**2*(1.-NU)+
                    1C**2)/(D**2-C**2)-NU))
 0005                RETURN
 0006                END
```

```
FORTRAN IV G LEVEL  21                  F6                DATE = 77166          13/51/23            PAGE 0002

  *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = F6       , LINECNT =       55
  *STATISTICS*    SOURCE STATEMENTS =        6,PROGRAM SIZE =      472
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                F7                DATE = 77166          13/51/23          PAGE 0001

              FUNCTION F7(A,DELA,DELAD,P2)
              F7=(A+DELA)*DELAD*P2
              RETURN
              END
```

```
FORTRAN IV G LEVEL  21                F7                DATE = 77166          13/51/23          PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = F7       , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        4,PROGRAM SIZE =       374
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                  F8                 DATE = 77166          13/51/23             PAGE 0001

                   FUNCTION F8(D,DELD,DELDD,P2)
                   F8=(D+DELD)*DELDD*P2
                   RETURN
                   END
```

```
FORTRAN IV G LEVEL  21                  F8                 DATE = 77166          13/51/23             PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = F8       , LINECNT =        55
 *STATISTICS*    SOURCE STATEMENTS =        4,PROGRAM SIZE =      374
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                F9                DATE = 77166        13/51/23          PAGE 0001

                      FUNCTION F9(V,P2,P2D,N)
                      REAL L1,L2,L3,L4,MR,N,NU,I,J
                      F9=V*P2*P2D/(N*P2+132500.)
                      RETURN
                      END
```

```
FORTRAN IV G LEVEL  21                F9                DATE = 77166        13/51/23          PAGE 0002

  *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = F9      , LINECNT =       55
  *STATISTICS*    SOURCE STATEMENTS =        5,PROGRAM SIZE =      388
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                 LINEAR            DATE = 77166          13/51/23              PAGE 0001

 0001                SUBROUTINE LINEAR(A,X,Y,VV)
 0002                DIMENSION X(81),Y(81)
 0003                I=1
              C    1 IF(Y(I+1) .LT. Y(I)) GO TO 100
              C         USE FOLLOWING IF AS Y INCREASES X INCREASES
 0004             10 IF(A-X(I))3,2,2
              C         USE FOLLOWING IF AS Y INCREASES X DECREASES
              C  100 IF(A-X(I))2,2,3
 0005              2 I=I+1
 0006                GO TO 10
 0007              3 I=I-1
 0008                VV=Y(I)*(A-X(I+1))/(X(I)-X(I+1))+Y(I+1)*(A-X(I))/(X(I+1)-X(I))
 0009                RETURN
 0010                END
```

```
FORTRAN IV G LEVEL  21                 LINEAR            DATE = 77166          13/51/23              PAGE 0002

  *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = LINEAR  , LINECNT =       55
  *STATISTICS*    SOURCE STATEMENTS =       10,PROGRAM SIZE =      506
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                SGN                 DATE = 77166          13/51/23              PAGE 0001

               FUNCTION SGN(XX)
               IF(XX) 1,2,2
             1 SGN=-1.
               GO TO 3
             2 SGN=1.
             3 RETURN
               END
```

```
FORTRAN IV G LEVEL  21                SGN                 DATE = 77166          13/51/23              PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = SGN      , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        7,PROGRAM SIZE =      346
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                KUTTA              DATE = 77166          13/51/23            PAGE 0001

              SUBROUTINE KUTTA(X,XD,P1,P2)
              COMMON/BLK1/H,HH
              AK1=H*F1(X,XD,P1,P2)
              ZX=X+HH*XD+H*AK1/8.
              ZXD=XD+AK1/2.
              AK2=H*F1(ZX,ZXD,P1,P2)
              ZXD=XD+AK2/2.
              AK3=H*F1(ZX,ZXD,P1,P2)
              ZX=X+H*XD+HH*AK3
              ZXD=XD+AK3
              AK4=H*F1(ZX,ZXD,P1,P2)
              X=X+H*(XD+(AK1+AK2+AK3)/6.)
              XD=XD+(AK1+2.*(AK2+AK3)+AK4)/6.
              RETURN
              END
```

```
FORTRAN IV G LEVEL  21                KUTTA              DATE = 77166          13/51/23            PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = KUTTA    , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =       15,PROGRAM SIZE =      690
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                PBF                DATE = 77166          13/51/23            PAGE 0001

                FUNCTION PRF(XXX)
                COMMON/BLK3/IP,PB1,PB2,PB3
                IF(IP.GT.1) GO TO 1
                PRF=PB1
                IP=IP+1
                RETURN
              1 IF(IP.GT.2) GO TO 2
                PBF=PB2
                IP=IP+1
                RETURN
              2 IF(IP.GT.3) GO TO 3
                PRF=PB2
                IP=IP+1
                RETURN
              3 PBF=PB3
              4 RETURN
                END
```

```
FORTRAN IV G LEVEL  21                PBF                DATE = 77166          13/51/23            PAGE 0002

*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
*OPTIONS IN EFFECT*  NAME = PBF      , LINECNT =       55
*STATISTICS*    SOURCE STATEMENTS =       17,PROGRAM SIZE =       482
*STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                DQG4             DATE = 77166          13/51/23             PAGE 0001

                      SUBROUTINE DQG4(XL,XU,FCT,Y)
                      A=.5*(XU+XL)
                      B=XU-XL
                      C=.4305681557970262 9*B
                      Y=.1739274225687269 3*(FCT(A+C)+FCT(A-C))
                      C=.1699905217924281 3*B
                      Y=B*(Y+.3260725774312730 7*(FCT(A+C)+FCT(A-C)))
                      RETURN
                      END
```

```
FORTRAN IV G LEVEL  21                DQG4             DATE = 77166          13/51/23             PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = DQG4     , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =         9,PROGRAM SIZE =       586
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                KUTTA1             DATE = 77166          13/51/23             PAGE 0001

      SUBROUTINE KUTTA1(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
      COMMON/BLK1/H,HH
      AK1=H*F2(X,XD,P1,P2)
      AL1=H*F3(X,XD,P1,P2,P3,DELA,DELAD,DELD,DELDD)
      AM1=H*F4(X,XD,P2,P3)
      ZP1=P1+AK1/2.
      ZP2=P2+AL1/2.
      ZP3=P3+AM1/2.
      AK2=H*F2(X,XD,ZP1,ZP2)
      AL2=H*F3(X,XD,ZP1,ZP2,ZP3,DELA,DELAD,DELD,DELDD)
      AM2=H*F4(X,XD,ZP2,ZP3)
      ZP1=P1+AK2/2.
      ZP2=P2+AL2/2.
      ZP3=P3+AM2/2.
      AK3=H*F2(X,XD,ZP1,ZP2)
      AL3=H*F3(X,XD,ZP1,ZP2,ZP3,DELA,DELAD,DELD,DELDD)
      AM3=H*F4(X,XD,ZP2,ZP3)
      ZP1=P1+AK3
      ZP2=P2+AL3
      ZP3=P3+AM3
      AK4=H*F2(X,XD,ZP1,ZP2)
      AL4=H*F3(X,XD,ZP1,ZP2,ZP3,DELA,DELAD,DELD,DELDD)
      AM4=H*F4(X,XD,ZP2,ZP3)
      P1=P1+1./6.*(AK1+2.*AK2+2.*AK3+AK4)
      P2=P2+1./6.*(AL1+2.*AL2+2.*AL3+AL4)
      P3=P3+1./6.*(AM1+2.*AM2+2.*AM3+AM4)
      RETURN
      END
```

```
FORTRAN IV G LEVEL  21                KUTTA1             DATE = 77166          13/51/23             PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = KUTTA1  , LINECNT =       55
 *STATISTICS*    SOURCE STATEMENTS =        28,PROGRAM SIZE =      1308
 *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                  KUTTA2              DATE = 77166            13/51/23             PAGE 0001

                    SUBROUTINE KUTTA2(DELA,DELD,DELAD,DELDD,P2)
                    COMMON/BLK1/H,HH
                    AK1=H*F5(DELA,DELAD,P2)
                    AL1=H*F6(DELD,DELDD,P2)
                    ZDELA=DELA+HH*DELAD+H*AK1/8.
                    ZDELD=DELD+HH*DELDD+H*AL1/8.
                    ZDELAD=DFLAD+AK1/2.
                    ZDELDD=DELDD+AL1/2.
                    AK2=H*F5(7DELA,ZDELAD,P2)
                    AL2=H*F6(ZDELD,ZDELDD,P2)
                    ZDELAD=DELAD+AK2/2.
                    ZDELDD=DELDD+AL2/2.
                    AK3=H*F5(ZDELA,ZDELAD,P2)
                    AL3=H*F6(ZDELD,ZDELDD,P2)
                    ZDELA=DELA+H*DELAD+HH*AK3
                    ZDELD=DELD+H*DELDD+HH*AL3
                    ZDELAD=DELAD+AK3
                    ZDELDD=DELDD+AL3
                    AK4=H*F5(ZDELA,ZDELAD,P2)
                    AL4=H*F6(ZDELD,ZDELDD,P2)
                    DELA=DELA+H*(DELAD+(AK1+AK2+AK3)/6.)
                    DELD=DELD+H*(DELDD+(AL1+AL2+AL3)/6.)
                    DELAD=DELAD+(AK1+2.*(AK2+AK3)+AK4)/6.
                    DELDD=DELDD+(AL1+2.*(AL2+AL3)+AL4)/6.
                    RETURN
                    END
```

```
FORTRAN IV G LEVEL  21                  KUTTA2              DATE = 77166            13/51/23             PAGE 0002

 *OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
 *OPTIONS IN EFFECT*  NAME = KUTTA2  , LINECNT =        55
 *STATISTICS*    SOURCE STATEMENTS =        26,PROGRAM SIZE =     1012
 *STATISTICS*  NO DIAGNOSTICS GENERATED

 *STATISTICS*  NO DIAGNOSTICS THIS STEP
```

```
F88-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST,LET,XREF
          DEFAULT OPTION(S) USED -  SIZE=(92160,8192)
****MAIN       DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
```

CROSS REFERENCE TABLE

CONTROL SECTION			ENTRY							
NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
MAIN	00	157C								
AF	1580	1E4								
AR	1768	17C								
QF	18E8	1DE								
QR	1AC8	1DE								
F1	1CA8	26A								
F2	1F18	208								
F3	2120	3CA								
F4	24F0	202								
F5	26F8	1D8								
F6	28D0	1D8								
F7	2AA8	176								
F8	2C20	176								
F9	2D98	184								
LINEAR	2F20	1FA								
SGN	3120	15A								
KUTTA	3280	2B2								
PBF	3538	1E2								
DQG4	3720	24A								
KUTTA1	3970	51C								
KUTTA2	3E90	3F4								
IHNFEXIT*	4288	1C	EXIT	4288						
IHNNAMEL*	42A8	AAF	FRDNL#	42A8	FWRNL#	4898				
IHNECOMH*	4D58	F8C	IBCOM#	4DB4	FDIOCS#	4E40	INTSWTCH	5CBE		
IHNCOMH2*	5CE8	715	SEQDASD	6116						
IHNSSCN *	6400	208	COS	6400	SIN	6422				
IHNSSQRT*	6608	168	SQRT	6608						
IHNFCVTH*	6770	86F	ADCON#	6770	FCVAOUTP	681A	FCVLOUTP	68AA	FCVZOUTP	6A06
			FCVIOUTP	6DAE	FCVEOUTP	6EA0	FCVCOUTP	6FEA	INT6SWCH	7260
IHNEFNTH*	72E0	548	ARITH#	72E0	ADJSWTCH	767C				
IHNEFIOS*	7828	FF8	FIOCS#	7828	FIOCSBEP	782E				
IHNFIOS2*	8820	5B8								
IHNERRM *	8DD8	5FC	ERRMON	8DD8	IHNERRE	8DF0				

NAME	ORIGIN	LENGTH	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
IHNUOPT *	93D8	318								
IHNFCONI*	96F0	2E5	FQCONI#	96F0						
IHNFCONO*	99D8	4A2	FQCONO#	99D8						
IHNETRCH*	9E80	2A6	IHNTRCH	9E80	ERRTRA	9E88				
IHNUATBL*	A128	638								
IHNFTEN *	A760	198	FTEN#	A760						
BLK1	A8F8	8								
BLK2	A900	24								
BLK3	A928	10								
BLK4	A938	48								
BLK5	A980	28								

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
388	BLK4	BLK4
39C	BLK4	BLK4
3C8	BLK3	BLK3
198	F7	F7
1A0	F9	F9
1A8	FRDNL#	IHNNAMEL
1B0	LINEAR	LINEAR
1B8	F1	F1
1C0	F5	F5
71C	BLK5	BLK5
73C	BLK5	BLK5
75C	BLK4	BLK4
77C	BLK4	BLK4
79C	BLK4	BLK4
7BC	BLK4	BLK4
7DC	BLK4	BLK4
7FC	BLK4	BLK4
81C	BLK4	BLK4
84C	BLK4	BLK4
7C	BLK2	BLK2
84	BLK4	BLK4
1EC	BLK3	BLK3
20C	BLK3	BLK3
1C8	KUTTA1	KUTTA1
1D0	F3	F3
1D8	EXIT	IHNFEXIT
6FC	BLK5	BLK5
15F8	BLK4	BLK4
17E0	BLK4	BLK4
1980	SGN	SGN
1960	BLK4	BLK4
1860	SGN	SGN

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
3BC	BLK4	BLK4
3B8	BLK3	BLK3
3D8	BLK3	BLK3
19C	F8	F8
1A4	IBCOM#	IHNECOMH
1AC	FWRNL#	IHNNAMEL
1B4	KUTTA	KUTTA
1BC	KUTTA2	KUTTA2
70C	BLK5	BLK5
72C	BLK5	BLK5
74C	BLK4	BLK4
76C	BLK4	BLK4
78C	BLK4	BLK4
7AC	BLK4	BLK4
7CC	BLK4	BLK4
7EC	BLK4	BLK4
80C	BLK4	BLK4
82C	BLK4	BLK4
78	BLK1	BLK1
80	BLK3	BLK3
88	BLK5	BLK5
1FC	BLK3	BLK3
1C4	F6	F6
1CC	F2	F2
1D4	F4	F4
1DC	SQRT	IHNSSQRT
15FC	BLK5	BLK5
17E4	BLK5	BLK5
197C	AF	AF
1984	SQRT	IHNSSQRT
1B5C	AR	AR
1B64	SQRT	IHNSSQRT

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
1B40	BLK4	BLK4
1D28	BLK5	BLK5
1D4C	PRF	PRF
1D20	BLK2	BLK2
2570	BLK5	BLK5
2590	AR	AR
2770	BLK4	BLK4
1F94	BLK4	BLK4
1FB4	QF	QF
1F90	BLK2	BLK2
21A0	BLK5	BLK5
21C8	QR	QR
21D0	AF	AF
3314	F1	F1
35B0	BLK3	BLK3
3A08	F3	F3
39E8	BLK1	BLK1
3F28	F6	F6
42A0	IBCOM#	IHNECOMH
4B30	ADCON#	IHNFCVTH
4C14	IHNERRM	IHNERRM
4E98	IHNCOMH2	IHNCOMH2
5BBC	FIOCS#	IHNEFIOS
5BE8	ADJSWTCH	IHNEFNTH
5CE0	IHNCMSE	$UNRESOLVED(W)
5BD0	FCVLOUTP	IHNFCVTH
5BD8	FCVCOUTP	IHNFCVTH
5BE0	FCVZOUTP	IHNFCVTH
5B9C	IHNCOMH2	IHNCOMH2
5B74	IHNCOMH2	IHNCOMH2
5B7C	IHNCOMH2	IHNCOMH2
5F80	IHNECOMH	IHNECOMH
5FDC	IHNECOMH	IHNECOMH
5D2C	IBCOM#	IHNECOMH
626D	IHNECOMH	IHNECOMH
6550	IBCOM#	IHNECOMH
66EC	IBCOM#	IHNECOMH
70D0	IBCOM#	IHNECOMH
7120	FQCONO#	IHNFCONO
76CC	IBCOM#	IHNECOMH
7678	INT6SWCH	IHNFCVTH
76D8	ADCON#	IHNFCVTH
7744	IHNERRM	IHNERRM
798C	IHNFIOS2	IHNFIOS2
8638	IBCOM#	IHNECOMH
8664	IHNFIOS2	IHNFIOS2
93C4	IHNUOPT	IHNUOPT
93CC	IHNTRCH	IHNETRCH
996C	FTEN#	IHNFTEN
A010	LDFIO#	$UNRESOLVED(W)
A00C	ADCON#	IHNFCVTH

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
1D24	BLK4	BLK4
1D58	BLK4	BLK4
1D50	SIN	IHNSSCN
256C	BLK4	BLK4
258C	QR	QR
2568	BLK2	BLK2
2948	BLK4	BLK4
1F98	BLK5	BLK5
1FB8	AF	AF
219C	BLK4	BLK4
21C4	QF	QF
21CC	AR	AR
2198	BLK2	BLK2
32F8	BLK1	BLK1
3A04	F2	F2
3A0C	F4	F4
3F24	F5	F5
3F08	BLK1	BLK1
4B28	IBCOM#	IHNECOMH
4B2C	FIOCS#	IHNEFIOS
4E40	SEQDASD	IHNCOMH2
5BC4	ADCON#	IHNFCVTH
5BC8	ARITH#	IHNEFNTH
5BE4	IHNUOPT	IHNUOPT
5BCC	FCVEOUTP	IHNFCVTH
5BD4	FCVIOUTP	IHNFCVTH
5BDC	FCVAOUTP	IHNFCVTH
5B70	IHNERRE	IHNERRM
5BA0	IHNERRM	IHNERRM
5B78	IHNCOMH2	IHNCOMH2
5B80	IHNCOMH2	IHNCOMH2
5FD9	IHNECOMH	IHNECOMH
5D30	IHNERRM	IHNERRM
625D	IHNECOMH	IHNECOMH
627D	IHNECOMH	IHNECOMH
6594	IHNERRM	IHNERRM
6714	IHNERRM	IHNERRM
70CC	IHNERRM	IHNERRM
7124	FQCONI#	IHNFCONI
76D0	INTSWTCH	IHNECOMH
7674	IHNUOPT	IHNUOPT
76D4	FIOCS#	IHNEFIOS
7988	IHNERRM	IHNERRM
862C	IHNUATBL	IHNUATBL
864D	IHNFIOS2	IHNFIOS2
8819	IHNFIOS2	IHNFIOS2
93C8	IBCOM#	IHNECOMH
93D0	FIOCSBEP	IHNEFIOS
9DC8	FTEN#	IHNFTEN
A008	IBCOM#	IHNECOMH
A014	FIOCSBEP	IHNEFIOS

```
ENTRY ADDRESS      00
TOTAL LENGTH     A9A8
```

```
&NAM
R1=  8.19999981    ,R2=  8.19999981    ,R3=  8.14999962    ,R4=  7.62500000    ,R5=  7.25000000    ,A=  11.2500000    ,B=
  11.8500004    ,C=  6.50000000    ,D=  7.25000000    ,G=  386.000000    ,CD= .949999988    ,RHOF= .339419991E-01,RHOS=
  .732999993E-03,L1=  20.0000000    ,L2=  20.0000000    ,L3=  20.0000000    ,E=  29000000.0    ,N=  12.6700001    ,NU=
  .287000000    ,V0=  .0                ,WR=  6500.00000    ,GAMMA=  .785399973
&END
&NAM1
TIME=  .0             ,  .500000082E-03,  .999999931E-03,  .150000001E-02,  .200000009E-02,  .249999994E-02,  .300000003E-02,
  .350000011E-02,  .400000066E-02,  .450000167E-02,  .499999896E-02,  .516000018E-02,  .549999997E-02,  .600000098E-02,
  .649999827E-02,  .699999928E-02,  .750000030E-02,  .800000131E-02,  .849999860E-02,  .899999961E-02,  .950000063E-02,
  .100000016E-01,  .104999989E-01,  .109999999E-01,  .115000010E-01,  .118400007E-01,  .119999982E-01,  .139999986E-01,
  .159999989E-01,  .179999992E-01,  .199999996E-01,  .219999999E-01,  .240000002E-01,  .260000005E-01,  .280000009E-01,
  .300000012E-01,  .320000015E-01,  .340000018E-01,  .359999985E-01,  .379999988E-01,  .399999991E-01,  .419999994E-01,
  .439999998E-01,  .460000001E-01,  .480000004E-01,  .500000007E-01,  .520000011E-01,  .540000014E-01,  .560000017E-01,
  .579999983E-01,  .599999987E-01,  .619999990E-01,  .640000105E-01,  .659999847E-01,  .680000186E-01,  .699999928E-01,
  .720000267E-01,  .740000010E-01,  .759999752E-01,  .780000091E-01,  .799999833E-01,  .820000172E-01,  .839999914E-01,
  .860000253E-01,  .879999995E-01,  .899999738E-01,  .920000076E-01,  .939999819E-01,  .960000157E-01,  .979999900E-01,
  .100000024     ,  .101999998     ,  .103999972     ,  .106000006     ,  .107999980     ,  .110000014     ,  .111999989     ,
  .114000022     ,  .115999997     ,  .117999971     ,  100.000000     ,BFORCE=  67473.0000     ,  106899.000     ,  167919.000
   260269.000    ,  395281.000    ,  582503.000    ,  822441.000    ,  1096656.00    ,  1362629.00    ,  1564534.00    ,
   1659798.00    ,  1665477.00    ,  1640974.00    ,  1533628.00    ,  1376528.00    ,  1203555.00    ,  1036586.00    ,
   886495.000    ,  756855.000    ,  647295.000    ,  555708.000    ,  479461.000    ,  415985.000    ,  363006.000    ,
   318605.000    ,  292400.000    ,  288254.000    ,  241195.000    ,  202470.000    ,  170490.000    ,  143994.000    ,
   121966.000    ,  103598.000    ,  88235.0000    ,  75346.0000    ,  64503.0000    ,  55356.0000    ,  47619.0000    ,
   41058.0000    ,  35480.0000    ,  30727.0000    ,  26666.0000    ,  23189.0000    ,  20206.0000    ,  17640.0000    ,
   15430.0000    ,  13520.0000    ,  11869.0000    ,  10437.0000    ,  9193.00000    ,  8111.00000    ,  7167.00000    ,
   6343.00000    ,  5623.00000    ,  4991.00000    ,  4437.00000    ,  3950.00000    ,  3522.00000    ,  3144.00000    ,
   2810.00000    ,  2515.00000    ,  2254.00000    ,  2022.00000    ,  1817.00000    ,  1634.00000    ,  1471.00000    ,
   1326.00000    ,  1197.00000    ,  1081.00000    ,  978.000000    ,  885.000000    ,  802.000000    ,  727.000000    ,
   660.000000    ,  600.000000    ,  546.000000    ,  497.000000    ,  453.000000    ,  413.000000    ,  377.000000    ,
  .0
&END
T=0.0019 X=20.004 XD=     4.17 XDD=   2080.0 P1=  2999.51 P1D=       0.0 P2=  2999.51 P2D=    -448.8 P3=  2999.51 P3D=     0.0
DELA= 0.0197 DELAD=-0.0033 DELD=-0.0056 DELDD= 0.0007 SIGT=   57779.5 SIGAX=   27390.0 SIGR=   -2999.5 SIGE=   37219.3
T=0.0039 X=20.016 XD=     8.33 XDD=   2078.9 P1=  2998.08 P1D=       0.0 P2=  2998.08 P2D=    -925.5 P3=  2998.08 P3D=     0.0
DELA= 0.0197 DELAD=-0.0061 DELD=-0.0056 DELDD= 0.0013 SIGT=   57752.0 SIGAX=   27377.0 SIGR=   -2998.1 SIGE=   37201.6
T=0.0059 X=20.037 XD=    12.49 XDD=   2077.0 P1=  2995.72 P1D=       0.0 P2=  2995.72 P2D=   -1424.2 P3=  2995.72 P3D=     0.0
DELA= 0.0197 DELAD=-0.0083 DELD=-0.0056 DELDD= 0.0022 SIGT=   57706.4 SIGAX=   27355.4 SIGR=   -2995.7 SIGE=   37172.3
T=0.0079 X=20.065 XD=    16.64 XDD=   2074.5 P1=  2992.42 P1D=       0.0 P2=  2992.42 P2D=   -1892.0 P3=  2992.42 P3D=     0.0
DELA= 0.0197 DELAD=-0.0110 DELD=-0.0056 DELDD= 0.0032 SIGT=   57642.9 SIGAX=   27325.3 SIGR=   -2992.4 SIGE=   37131.4
T=0.0099 X=20.103 XD=    20.78 XDD=   2071.2 P1=  2988.19 P1D=       0.0 P2=  2988.19 P2D=   -2308.3 P3=  2988.19 P3D=     0.0
DELA= 0.0196 DELAD=-0.0150 DELD=-0.0056 DELDD= 0.0035 SIGT=   57561.4 SIGAX=   27286.6 SIGR=   -2988.2 SIGE=   37078.9
T=0.0119 X=20.148 XD=    24.92 XDD=   2067.1 P1=  2983.02 P1D=       0.0 P2=  2983.02 P2D=   -2752.3 P3=  2983.02 P3D=     0.0
DELA= 0.0196 DELAD=-0.0184 DELD=-0.0056 DELDD= 0.0040 SIGT=   57461.9 SIGAX=   27239.5 SIGR=   -2983.0 SIGE=   37014.8
T=0.0139 X=20.202 XD=    29.05 XDD=   2062.4 P1=  2976.93 P1D=       0.0 P2=  2976.93 P2D=   -3293.0 P3=  2976.93 P3D=     0.0
DELA= 0.0196 DELAD=-0.0193 DELD=-0.0055 DELDD= 0.0055 SIGT=   57344.5 SIGAX=   27183.8 SIGR=   -2976.9 SIGE=   36939.2
T=0.0159 X=20.264 XD=    33.17 XDD=   2056.9 P1=  2969.92 P1D=       0.0 P2=  2969.92 P2D=   -3773.6 P3=  2969.92 P3D=     0.0
DELA= 0.0195 DELAD=-0.0219 DELD=-0.0055 DELDD= 0.0060 SIGT=   57209.5 SIGAX=   27119.8 SIGR=   -2969.9 SIGE=   36852.2
T=0.0179 X=20.334 XD=    37.28 XDD=   2050.7 P1=  2961.98 P1D=       0.0 P2=  2961.98 P2D=   -4130.2 P3=  2961.98 P3D=     0.0
DELA= 0.0195 DELAD=-0.0269 DELD=-0.0055 DELDD= 0.0064 SIGT=   57056.6 SIGAX=   27047.3 SIGR=   -2962.0 SIGE=   36753.7
T=0.0199 X=20.412 XD=    41.37 XDD=   2043.7 P1=  2953.12 P1D=       0.0 P2=  2953.12 P2D=   -4643.7 P3=  2953.12 P3D=     0.0
DELA= 0.0194 DELAD=-0.0286 DELD=-0.0055 DELDD= 0.0072 SIGT=   56885.9 SIGAX=   26966.4 SIGR=   -2953.1 SIGE=   36643.7
T=0.0219 X=20.499 XD=    45.45 XDD=   2036.1 P1=  2943.36 P1D=       0.0 P2=  2943.36 P2D=   -5156.1 P3=  2943.36 P3D=     0.0
DELA= 0.0193 DELAD=-0.0301 DELD=-0.0055 DELDD= 0.0082 SIGT=   56697.8 SIGAX=   26877.2 SIGR=   -2943.4 SIGE=   36522.6
T=0.0239 X=20.593 XD=    49.52 XDD=   2027.7 P1=  2932.68 P1D=       0.0 P2=  2932.68 P2D=   -5513.9 P3=  2932.68 P3D=     0.0
DELA= 0.0193 DELAD=-0.0352 DELD=-0.0055 DELDD= 0.0081 SIGT=   56492.1 SIGAX=   26779.8 SIGR=   -2932.7 SIGE=   36390.1
T=0.0259 X=20.696 XD=    53.56 XDD=   2018.7 P1=  2921.10 P1D=       0.0 P2=  2921.10 P2D=   -5924.2 P3=  2921.10 P3D=     0.0
DELA= 0.0192 DELAD=-0.0387 DELD=-0.0054 DELDD= 0.0090 SIGT=   56269.0 SIGAX=   26674.0 SIGR=   -2921.1 SIGE=   36246.4
T=0.0279 X=20.807 XD=    57.59 XDD=   2008.9 P1=  2908.62 P1D=       0.0 P2=  2908.62 P2D=   -6465.9 P3=  2908.62 P3D=     0.0
DELA= 0.0191 DELAD=-0.0391 DELD=-0.0054 DELDD= 0.0105 SIGT=   56028.7 SIGAX=   26560.0 SIGR=   -2908.6 SIGE=   36091.5
T=0.0299 X=20.926 XD=    61.60 XDD=   1998.4 P1=  2895.26 P1D=       0.0 P2=  2895.26 P2D=   -6967.6 P3=  2895.26 P3D=     0.0
DELA= 0.0190 DELAD=-0.0409 DELD=-0.0054 DELDD= 0.0109 SIGT=   55771.3 SIGAX=   26438.0 SIGR=   -2895.3 SIGE=   35925.8
T=0.0319 X=21.053 XD=    65.58 XDD=   1987.3 P1=  2881.01 P1D=       0.0 P2=  2881.01 P2D=   -7264.5 P3=  2881.01 P3D=     0.0
DELA= 0.0189 DELAD=-0.0465 DELD=-0.0054 DELDD= 0.0112 SIGT=   55496.9 SIGAX=   26307.9 SIGR=   -2881.0 SIGE=   35749.0
```

```
T=0.0339 X=21.188 XD=    69.54 XDD=   1975.4 P1=  2865.88 P1D=      0.0 P2=  2865.88 P2D=   -7733.6 P3=  2865.88 P3D=    0.0
DELA= 0.0188 DELAD=-0.0484 DELD=-0.0053 DELDD= 0.0121 SIGT=   55205.4 SIGAX=  26169.8 SIGR=   -2865.9 SIGE=   35561.2
T=0.0359 X=21.330 XD=    73.48 XDD=   1962.9 P1=  2849.89 P1D=      0.0 P2=  2849.89 P2D=   -8276.5 P3=  2849.89 P3D=    0.0
DELA= 0.0187 DELAD=-0.0490 DELD=-0.0053 DELDD= 0.0128 SIGT=   54897.3 SIGAX=  26023.7 SIGR=   -2849.9 SIGE=   35362.8
T=0.0379 X=21.481 XD=    77.39 XDD=   1949.7 P1=  2833.04 P1D=      0.0 P2=  2833.04 P2D=   -8594.9 P3=  2833.04 P3D=    0.0
DELA= 0.0186 DELAD=-0.0537 DELD=-0.0053 DELDD= 0.0135 SIGT=   54572.7 SIGAX=  25869.9 SIGR=   -2833.0 SIGE=   35153.7
T=0.0399 X=21.639 XD=    81.28 XDD=   1935.8 P1=  2815.33 P1D=      0.0 P2=  2815.33 P2D=   -9022.3 P3=  2815.33 P3D=    0.0
DELA= 0.0185 DELAD=-0.0564 DELD=-0.0052 DELDD= 0.0139 SIGT=   54231.6 SIGAX=  25708.1 SIGR=   -2815.3 SIGE=   34933.9
T=0.0419 X=21.805 XD=    85.13 XDD=   1921.3 P1=  2796.78 P1D=      0.0 P2=  2796.78 P2D=   -9500.4 P3=  2796.78 P3D=    0.0
DELA= 0.0184 DELAD=-0.0576 DELD=-0.0052 DELDD= 0.0149 SIGT=   53874.2 SIGAX=  25538.8 SIGR=   -2796.8 SIGE=   34703.7
T=0.0439 X=21.979 XD=    88.96 XDD=   1906.1 P1=  2777.40 P1D=      0.0 P2=  2777.40 P2D=   -9923.0 P3=  2777.40 P3D=    0.0
DELA= 0.0182 DELAD=-0.0601 DELD=-0.0052 DELDD= 0.0154 SIGT=   53500.9 SIGAX=  25361.8 SIGR=   -2777.4 SIGE=   34463.3
T=0.0459 X=22.161 XD=    92.76 XDD=   1890.3 P1=  2757.19 P1D=      0.0 P2=  2757.19 P2D=  -10235.4 P3=  2757.19 P3D=    0.0
DELA= 0.0181 DELAD=-0.0647 DELD=-0.0051 DELDD= 0.0156 SIGT=   53111.7 SIGAX=  25177.3 SIGR=   -2757.2 SIGE=   34212.5
T=0.0479 X=22.350 XD=    96.52 XDD=   1873.8 P1=  2736.16 P1D=      0.0 P2=  2736.16 P2D=  -10696.6 P3=  2736.16 P3D=    0.0
DELA= 0.0180 DELAD=-0.0660 DELD=-0.0051 DELDD= 0.0165 SIGT=   52706.6 SIGAX=  24985.2 SIGR=   -2736.2 SIGE=   33951.6
T=0.0499 X=22.546 XD=   100.25 XDD=   1856.7 P1=  2714.34 P1D=      0.0 P2=  2714.34 P2D=  -11183.4 P3=  2714.34 P3D=    0.0
DELA= 0.0178 DELAD=-0.0665 DELD=-0.0051 DELDD= 0.0175 SIGT=   52286.2 SIGAX=  24786.0 SIGR=   -2714.3 SIGE=   33680.8
T=0.0519 X=22.750 XD=   103.95 XDD=   1839.0 P1=  2691.72 P1D=      0.0 P2=  2691.72 P2D=  -11465.9 P3=  2691.72 P3D=    0.0
DELA= 0.0177 DELAD=-0.0712 DELD=-0.0050 DELDD= 0.0179 SIGT=   51850.6 SIGAX=  24579.4 SIGR=   -2691.7 SIGE=   33400.2
T=0.0539 X=22.961 XD=   107.60 XDD=   1820.6 P1=  2668.32 P1D=      0.0 P2=  2668.32 P2D=  -11841.9 P3=  2668.32 P3D=    0.0
DELA= 0.0175 DELAD=-0.0741 DELD=-0.0050 DELDD= 0.0181 SIGT=   51399.7 SIGAX=  24365.7 SIGR=   -2668.3 SIGE=   33109.7
T=0.0559 X=23.180 XD=   111.23 XDD=   1801.7 P1=  2644.14 P1D=      0.0 P2=  2644.14 P2D=  -12340.7 P3=  2644.14 P3D=    0.0
DELA= 0.0174 DELAD=-0.0739 DELD=-0.0049 DELDD= 0.0191 SIGT=   50934.1 SIGAX=  24145.0 SIGR=   -2644.1 SIGE=   32809.8
T=0.0579 X=23.405 XD=   114.81 XDD=   1782.1 P1=  2619.22 P1D=      0.0 P2=  2619.22 P2D=  -12661.7 P3=  2619.22 P3D=    0.0
DELA= 0.0172 DELAD=-0.0772 DELD=-0.0049 DELDD= 0.0198 SIGT=   50454.0 SIGAX=  23917.4 SIGR=   -2619.2 SIGE=   32500.5
T=0.0599 X=23.638 XD=   118.35 XDD=   1762.0 P1=  2593.54 P1D=      0.0 P2=  2593.54 P2D=  -12956.3 P3=  2593.54 P3D=    0.0
DELA= 0.0170 DELAD=-0.0811 DELD=-0.0048 DELDD= 0.0203 SIGT=   49959.3 SIGAX=  23682.9 SIGR=   -2593.5 SIGE=   32181.9
T=0.0619 X=23.878 XD=   121.85 XDD=   1741.3 P1=  2567.13 P1D=      0.0 P2=  2567.13 P2D=  -13380.2 P3=  2567.13 P3D=    0.0
DELA= 0.0169 DELAD=-0.0821 DELD=-0.0048 DELDD= 0.0209 SIGT=   49450.5 SIGAX=  23441.7 SIGR=   -2567.1 SIGE=   31854.2
T=0.0639 X=24.125 XD=   125.32 XDD=   1720.0 P1=  2540.00 P1D=      0.0 P2=  2540.00 P2D=  -13767.2 P3=  2540.00 P3D=    0.0
DELA= 0.0167 DELAD=-0.0836 DELD=-0.0047 DELDD= 0.0216 SIGT=   48927.9 SIGAX=  23194.0 SIGR=   -2540.0 SIGE=   31517.5
T=0.0659 X=24.379 XD=   128.73 XDD=   1698.2 P1=  2512.16 P1D=      0.0 P2=  2512.16 P2D=  -14074.1 P3=  2512.16 P3D=    0.0
DELA= 0.0165 DELAD=-0.0870 DELD=-0.0047 DELDD= 0.0215 SIGT=   48391.7 SIGAX=  22939.8 SIGR=   -2512.2 SIGE=   31172.1
T=0.0679 X=24.639 XD=   132.11 XDD=   1675.8 P1=  2483.62 P1D=      0.0 P2=  2483.62 P2D=  -14433.8 P3=  2483.62 P3D=    0.0
DELA= 0.0163 DELAD=-0.0887 DELD=-0.0046 DELDD= 0.0222 SIGT=   47842.0 SIGAX=  22679.2 SIGR=   -2483.6 SIGE=   30818.0
T=0.0699 X=24.907 XD=   135.43 XDD=   1652.9 P1=  2454.41 P1D=      0.0 P2=  2454.41 P2D=  -14804.4 P3=  2454.41 P3D=    0.0
DELA= 0.0161 DELAD=-0.0898 DELD=-0.0046 DELDD= 0.0233 SIGT=   47279.2 SIGAX=  22412.4 SIGR=   -2454.4 SIGE=   30455.5
T=0.0719 X=25.180 XD=   138.72 XDD=   1629.5 P1=  2424.53 P1D=      0.0 P2=  2424.53 P2D=  -15077.2 P3=  2424.53 P3D=    0.0
DELA= 0.0159 DELAD=-0.0933 DELD=-0.0045 DELDD= 0.0233 SIGT=   46703.6 SIGAX=  22139.6 SIGR=   -2424.5 SIGE=   30084.7
T=0.0739 X=25.461 XD=   141.95 XDD=   1605.6 P1=  2393.99 P1D=      0.0 P2=  2393.99 P2D=  -15414.6 P3=  2393.99 P3D=    0.0
DELA= 0.0157 DELAD=-0.0949 DELD=-0.0045 DELDD= 0.0239 SIGT=   46115.4 SIGAX=  21860.7 SIGR=   -2394.0 SIGE=   29705.8
T=0.0759 X=25.748 XD=   145.14 XDD=   1581.1 P1=  2362.82 P1D=      0.0 P2=  2362.82 P2D=  -15772.3 P3=  2362.82 P3D=    0.0
DELA= 0.0155 DELAD=-0.0958 DELD=-0.0044 DELDD= 0.0247 SIGT=   45514.9 SIGAX=  21576.0 SIGR=   -2362.8 SIGE=   29319.0
T=0.0779 X=26.041 XD=   148.27 XDD=   1556.2 P1=  2331.02 P1D=      0.0 P2=  2331.02 P2D=  -16011.8 P3=  2331.02 P3D=    0.0
DELA= 0.0153 DELAD=-0.0991 DELD=-0.0043 DELDD= 0.0252 SIGT=   44902.3 SIGAX=  21285.7 SIGR=   -2331.0 SIGE=   28924.4
T=0.0799 X=26.340 XD=   151.36 XDD=   1530.8 P1=  2298.61 P1D=      0.0 P2=  2298.61 P2D=  -16330.5 P3=  2298.61 P3D=    0.0
DELA= 0.0151 DELAD=-0.1007 DELD=-0.0043 DELDD= 0.0255 SIGT=   44278.0 SIGAX=  20989.7 SIGR=   -2298.6 SIGE=   28522.2
T=0.0819 X=26.646 XD=   154.39 XDD=   1504.9 P1=  2265.60 P1D=      0.0 P2=  2265.60 P2D=  -16675.6 P3=  2265.60 P3D=    0.0
DELA= 0.0149 DELAD=-0.1017 DELD=-0.0042 DELDD= 0.0256 SIGT=   43642.2 SIGAX=  20688.3 SIGR=   -2265.6 SIGE=   28112.7
T=0.0839 X=26.957 XD=   157.38 XDD=   1478.6 P1=  2232.02 P1D=      0.0 P2=  2232.02 P2D=  -16907.9 P3=  2232.02 P3D=    0.0
DELA= 0.0147 DELAD=-0.1043 DELD=-0.0042 DELDD= 0.0264 SIGT=   42995.3 SIGAX=  20381.7 SIGR=   -2232.0 SIGE=   27696.0
T=0.0859 X=27.274 XD=   160.31 XDD=   1451.8 P1=  2197.87 P1D=      0.0 P2=  2197.87 P2D=  -17198.1 P3=  2197.87 P3D=    0.0
DELA= 0.0144 DELAD=-0.1057 DELD=-0.0041 DELDD= 0.0270 SIGT=   42337.5 SIGAX=  20069.8 SIGR=   -2197.9 SIGE=   27272.2
T=0.0879 X=27.598 XD=   163.18 XDD=   1424.6 P1=  2163.17 P1D=      0.0 P2=  2163.17 P2D=  -17497.7 P3=  2163.17 P3D=    0.0
DELA= 0.0142 DELAD=-0.1070 DELD=-0.0040 DELDD= 0.0271 SIGT=   41669.2 SIGAX=  19753.0 SIGR=   -2163.2 SIGE=   26841.7
T=0.0899 X=27.926 XD=   166.00 XDD=   1397.0 P1=  2127.95 P1D=      0.0 P2=  2127.95 P2D=  -17754.4 P3=  2127.95 P3D=    0.0
DELA= 0.0140 DELAD=-0.1088 DELD=-0.0040 DELDD= 0.0274 SIGT=   40990.5 SIGAX=  19431.3 SIGR=   -2127.9 SIGE=   26404.6
T=0.0919 X=28.261 XD=   168.77 XDD=   1368.9 P1=  2092.20 P1D=      0.0 P2=  2092.20 P2D=  -17978.0 P3=  2092.20 P3D=    0.0
DELA= 0.0137 DELAD=-0.1107 DELD=-0.0039 DELDD= 0.0282 SIGT=   40301.9 SIGAX=  19104.9 SIGR=   -2092.2 SIGE=   25961.0
T=0.0939 X=28.601 XD=   171.47 XDD=   1340.5 P1=  2055.95 P1D=      0.0 P2=  2055.95 P2D=  -18259.8 P3=  2055.95 P3D=    0.0
DELA= 0.0135 DELAD=-0.1115 DELD=-0.0038 DELDD= 0.0286 SIGT=   39603.7 SIGAX=  18773.9 SIGR=   -2055.9 SIGE=   25511.2
T=0.0959 X=28.946 XD=   174.13 XDD=   1311.7 P1=  2019.22 P1D=      0.0 P2=  2019.22 P2D=  -18468.6 P3=  2019.22 P3D=    0.0
DELA= 0.0133 DELAD=-0.1137 DELD=-0.0038 DELDD= 0.0288 SIGT=   38896.1 SIGAX=  18438.5 SIGR=   -2019.2 SIGE=   25055.4
T=0.0979 X=29.297 XD=   176.72 XDD=   1282.5 P1=  1982.02 P1D=      0.0 P2=  1982.02 P2D=  -18701.0 P3=  1982.02 P3D=    0.0
```

```
DELA= 0.0130 DELAD=-0.1151 DELD=-0.0037 DELDD= 0.0292 SIGT=   38179.5 SIGAX=  18098.8 SIGR=  -1982.0 SIGE=  24593.8
T=0.0999 X=29.652 XD=  179.25 XDD=  1253.0 P1=  1944.36 P1D=       0.0 P2=  1944.36 P2D= -18957.8 P3=  1944.36 P3D=   0.0
DELA= 0.0128 DELAD=-0.1157 DELD=-0.0036 DELDD= 0.0296 SIGT=   37454.2 SIGAX=  17754.9 SIGR=  -1944.4 SIGE=  24126.6
T=0.1019 X=30.013 XD=  181.73 XDD=  1223.1 P1=  1906.27 P1D=       0.0 P2=  1906.27 P2D= -19123.1 P3=  1906.27 P3D=   0.0
DELA= 0.0125 DELAD=-0.1180 DELD=-0.0035 DELDD= 0.0300 SIGT=   36720.4 SIGAX=  17407.1 SIGR=  -1906.3 SIGE=  23653.9
T=0.1039 X=30.379 XD=  184.14 XDD=  1192.9 P1=  1867.76 P1D=       0.0 P2=  1867.76 P2D= -19348.8 P3=  1867.76 P3D=   0.0
DELA= 0.0123 DELAD=-0.1190 DELD=-0.0035 DELDD= 0.0301 SIGT=   35978.5 SIGAX=  17055.4 SIGR=  -1867.8 SIGE=  23176.0
T=0.1059 X=30.749 XD=  186.50 XDD=  1162.4 P1=  1828.84 P1D=       0.0 P2=  1828.84 P2D= -19586.8 P3=  1828.84 P3D=   0.0
DELA= 0.0120 DELAD=-0.1192 DELD=-0.0034 DELDD= 0.0306 SIGT=   35228.9 SIGAX=  16700.0 SIGR=  -1828.8 SIGE=  22693.1
T=0.1079 X=31.124 XD=  188.79 XDD=  1131.6 P1=  1789.54 P1D=       0.0 P2=  1789.54 P2D= -19712.9 P3=  1789.54 P3D=   0.0
DELA= 0.0118 DELAD=-0.1218 DELD=-0.0033 DELDD= 0.0308 SIGT=   34471.8 SIGAX=  16341.1 SIGR=  -1789.5 SIGE=  22205.4
T=0.1099 X=31.504 XD=  191.02 XDD=  1100.5 P1=  1749.86 P1D=       0.0 P2=  1749.86 P2D= -19911.2 P3=  1749.86 P3D=   0.0
DELA= 0.0115 DELAD=-0.1225 DELD=-0.0033 DELDD= 0.0311 SIGT=   33707.5 SIGAX=  15978.8 SIGR=  -1749.9 SIGE=  21713.1
T=0.1119 X=31.887 XD=  193.19 XDD=  1069.1 P1=  1709.83 P1D=       0.0 P2=  1709.83 P2D= -20130.1 P3=  1709.83 P3D=   0.0
DELA= 0.0112 DELAD=-0.1226 DELD=-0.0032 DELDD= 0.0315 SIGT=   32936.4 SIGAX=  15613.3 SIGR=  -1709.8 SIGE=  21216.4
T=0.1139 X=32.276 XD=  195.30 XDD=  1037.4 P1=  1669.46 P1D=       0.0 P2=  1669.46 P2D= -20228.1 P3=  1669.46 P3D=   0.0
DELA= 0.0110 DELAD=-0.1251 DELD=-0.0031 DELDD= 0.0315 SIGT=   32158.8 SIGAX=  15244.7 SIGR=  -1669.5 SIGE=  20715.5
T=0.1159 X=32.668 XD=  197.34 XDD=  1005.5 P1=  1628.77 P1D=       0.0 P2=  1628.77 P2D= -20426.4 P3=  1628.77 P3D=   0.0
DELA= 0.0107 DELAD=-0.1251 DELD=-0.0030 DELDD= 0.0320 SIGT=   31375.0 SIGAX=  14873.1 SIGR=  -1628.8 SIGE=  20210.6
T=0.1179 X=33.064 XD=  199.32 XDD=   973.4 P1=  1587.78 P1D=       0.0 P2=  1587.78 P2D= -20583.6 P3=  1587.78 P3D=   0.0
DELA= 0.0104 DELAD=-0.1258 DELD=-0.0030 DELDD= 0.0322 SIGT=   30585.3 SIGAX=  14498.8 SIGR=  -1587.8 SIGE=  19701.9
T=0.1199 X=33.465 XD=  201.23 XDD=   941.0 P1=  1546.49 P1D=       0.0 P2=  1546.49 P2D= -20687.9 P3=  1546.49 P3D=   0.0
DELA= 0.0102 DELAD=-0.1275 DELD=-0.0029 DELDD= 0.0323 SIGT=   29790.1 SIGAX=  14121.8 SIGR=  -1546.5 SIGE=  19189.6
T=0.1219 X=33.869 XD=  203.08 XDD=   908.4 P1=  1504.94 P1D=       0.0 P2=  1504.94 P2D= -20853.5 P3=  1504.94 P3D=   0.0
DELA= 0.0099 DELAD=-0.1276 DELD=-0.0028 DELDD= 0.0325 SIGT=   28989.6 SIGAX=  13742.3 SIGR=  -1504.9 SIGE=  18674.0
T=0.1239 X=34.276 XD=  204.86 XDD=   875.6 P1=  1463.13 P1D=       0.0 P2=  1463.13 P2D= -20948.3 P3=  1463.13 P3D=   0.0
DELA= 0.0096 DELAD=-0.1290 DELD=-0.0027 DELDD= 0.0328 SIGT=   28184.2 SIGAX=  13360.6 SIGR=  -1463.1 SIGE=  18155.2
T=0.1259 X=34.687 XD=  206.58 XDD=   842.6 P1=  1421.08 P1D=       0.0 P2=  1421.08 P2D= -21064.5 P3=  1421.08 P3D=   0.0
DELA= 0.0093 DELAD=-0.1297 DELD=-0.0026 DELDD= 0.0329 SIGT=   27374.2 SIGAX=  12976.5 SIGR=  -1421.1 SIGE=  17633.4
T=0.1279 X=35.102 XD=  208.23 XDD=   809.5 P1=  1378.80 P1D=       0.0 P2=  1378.80 P2D= -21214.8 P3=  1378.80 P3D=   0.0
DELA= 0.0091 DELAD=-0.1294 DELD=-0.0026 DELDD= 0.0332 SIGT=   26559.9 SIGAX=  12590.5 SIGR=  -1378.8 SIGE=  17108.9
T=0.1299 X=35.520 XD=  209.81 XDD=   776.1 P1=  1336.33 P1D=       0.0 P2=  1336.33 P2D= -21246.6 P3=  1336.33 P3D=   0.0
DELA= 0.0088 DELAD=-0.1315 DELD=-0.0025 DELDD= 0.0332 SIGT=   25741.6 SIGAX=  12202.6 SIGR=  -1336.3 SIGE=  16581.8
T=0.1319 X=35.941 XD=  211.33 XDD=   742.7 P1=  1293.65 P1D=       0.0 P2=  1293.65 P2D= -21384.3 P3=  1293.65 P3D=   0.0
DELA= 0.0085 DELAD=-0.1310 DELD=-0.0024 DELDD= 0.0334 SIGT=   24919.6 SIGAX=  11813.0 SIGR=  -1293.7 SIGE=  16052.3
T=0.1339 X=36.364 XD=  212.78 XDD=   709.1 P1=  1250.81 P1D=       0.0 P2=  1250.81 P2D= -21459.0 P3=  1250.81 P3D=   0.0
DELA= 0.0082 DELAD=-0.1318 DELD=-0.0023 DELDD= 0.0335 SIGT=   24094.3 SIGAX=  11421.8 SIGR=  -1250.8 SIGE=  15520.7
T=0.1359 X=36.791 XD=  214.16 XDD=   675.3 P1=  1207.81 P1D=       0.0 P2=  1207.81 P2D= -21517.4 P3=  1207.81 P3D=   0.0
DELA= 0.0079 DELAD=-0.1326 DELD=-0.0022 DELDD= 0.0336 SIGT=   23265.9 SIGAX=  11029.1 SIGR=  -1207.8 SIGE=  14987.0
T=0.1379 X=37.220 XD=  215.48 XDD=   641.5 P1=  1164.66 P1D=       0.0 P2=  1164.66 P2D= -21629.3 P3=  1164.66 P3D=   0.0
DELA= 0.0077 DELAD=-0.1320 DELD=-0.0022 DELDD= 0.0338 SIGT=   22434.8 SIGAX=  10635.1 SIGR=  -1164.7 SIGE=  14451.7
T=0.1399 X=37.652 XD=  216.73 XDD=   607.6 P1=  1121.39 P1D=       0.0 P2=  1121.39 P2D= -21626.6 P3=  1121.39 P3D=   0.0
DELA= 0.0074 DELAD=-0.1338 DELD=-0.0021 DELDD= 0.0338 SIGT=   21601.3 SIGAX=  10240.0 SIGR=  -1121.4 SIGE=  13914.7
T=0.1419 X=38.087 XD=  217.91 XDD=   573.5 P1=  1078.00 P1D=       0.0 P2=  1078.00 P2D= -21737.5 P3=  1078.00 P3D=   0.0
DELA= 0.0071 DELAD=-0.1327 DELD=-0.0020 DELDD= 0.0340 SIGT=   20765.6 SIGAX=   9843.8 SIGR=  -1078.0 SIGE=  13376.4
T=0.1439 X=38.523 XD=  219.02 XDD=   539.4 P1=  1034.53 P1D=       0.0 P2=  1034.53 P2D= -21752.8 P3=  1034.53 P3D=   0.0
DELA= 0.0068 DELAD=-0.1337 DELD=-0.0019 DELDD= 0.0339 SIGT=   19928.1 SIGAX=   9446.8 SIGR=  -1034.5 SIGE=  12836.9
T=0.1459 X=38.962 XD=  220.06 XDD=   505.3 P1=   990.97 P1D=       0.0 P2=   990.97 P2D= -21789.1 P3=   990.97 P3D=   0.0
DELA= 0.0065 DELAD=-0.1338 DELD=-0.0018 DELDD= 0.0341 SIGT=   19089.0 SIGAX=   9049.0 SIGR=   -991.0 SIGE=  12296.4
T=0.1479 X=39.403 XD=  221.04 XDD=   471.0 P1=   947.35 P1D=       0.0 P2=   947.35 P2D= -21830.9 P3=   947.35 P3D=   0.0
DELA= 0.0062 DELAD=-0.1337 DELD=-0.0018 DELDD= 0.0341 SIGT=   18248.7 SIGAX=   8650.7 SIGR=   -947.3 SIGE=  11755.1
T=0.1499 X=39.846 XD=  221.95 XDD=   436.8 P1=   903.67 P1D=       0.0 P2=   903.67 P2D= -21827.6 P3=   903.67 P3D=   0.0
DELA= 0.0059 DELAD=-0.1345 DELD=-0.0017 DELDD= 0.0341 SIGT=   17407.4 SIGAX=   8251.9 SIGR=   -903.7 SIGE=  11213.2
T=0.1519 X=40.290 XD=  222.77 XDD=   379.4 P1=   889.47 P1D=  762081.2 P2=   829.28 P2D= -38172.0 P3=   829.28 P3D=   0.0
DELA= 0.0055 DELAD=-0.2431 DELD=-0.0015 DELDD= 0.0988 SIGT=   15974.4 SIGAX=   7572.6 SIGR=   -829.3 SIGE=  10290.1
T=0.1539 X=40.736 XD=  223.45 XDD=   308.8 P1=   889.47 P1D=  385059.4 P2=   739.23 P2D= -28371.3 P3=   739.23 P3D=   0.0
DELA= 0.0049 DELAD=-0.2241 DELD=-0.0014 DELDD= 0.0665 SIGT=   14239.7 SIGAX=   6750.2 SIGR=   -739.2 SIGE=   9172.7
T=0.1559 X=41.183 XD=  224.00 XDD=   237.4 P1=   889.47 P1D=  122578.1 P2=   648.61 P2D= -13475.3 P3=   648.61 P3D=   0.0
DELA= 0.0043 DELAD=-0.3884 DELD=-0.0012 DELDD= 0.0606 SIGT=   12494.2 SIGAX=   5922.8 SIGR=   -648.6 SIGE=   8048.3
T=0.1578 X=41.631 XD=  224.40 XDD=   166.9 P1=   889.47 P1D=  -85619.8 P2=   558.26 P2D= -17634.1 P3=   558.26 P3D=   0.0
DELA= 0.0037 DELAD=-0.1496 DELD=-0.0010 DELDD= 0.0851 SIGT=   10753.7 SIGAX=   5097.7 SIGR=   -558.3 SIGE=   6927.2
T=0.1598 X=42.080 XD=  224.66 XDD=    96.2 P1=   889.47 P1D= -259756.6 P2=   468.53 P2D=  -3577.8 P3=   468.53 P3D=   0.0
DELA= 0.0031 DELAD=-0.3844 DELD=-0.0009 DELDD= 0.0568 SIGT=    9025.3 SIGAX=   4278.4 SIGR=   -468.5 SIGE=   5813.7
T=0.1618 X=42.529 XD=  224.78 XDD=    25.7 P1=   889.47 P1D= -412263.7 P2=   378.33 P2D=  -7063.2 P3=   378.33 P3D=   0.0
DELA= 0.0025 DELAD=-0.2067 DELD=-0.0007 DELDD= 0.0787 SIGT=    7287.8 SIGAX=   3454.7 SIGR=   -378.3 SIGE=   4694.5
```

```
T=0.1638 X=42.974 XD=   215.26 XDD= -12757.3 P1=   889.47 P1D= -617611.4 P2=   290.43 P2D=    1734.1 P3=   290.43 P3D=       0.0
DELA= 0.0019 DELAD=-0.2839 DELD=-0.0005 DELDD= 0.0633 SIGT=   5594.6 SIGAX=   2652.1 SIGR=   -290.4 SIGE=   3603.8
T=0.1658 X=43.357 XD=   153.25 XDD= -57085.0 P1=   889.47 P1D=-1214377.0 P2=   215.51 P2D=   18756.5 P3=   215.51 P3D=       0.0
DELA= 0.0014 DELAD=-0.1987 DELD=-0.0004 DELDD= 0.0439 SIGT=   4151.4 SIGAX=   1968.0 SIGR=   -215.5 SIGE=   2674.2
T=0.1678 X=43.510 XD=   -14.75 XDD= -98547.5 P1=   889.47 P1D=-2606387.0 P2=   188.71 P2D=   59003.5 P3=   188.71 P3D=       0.0
DELA= 0.0012 DELAD= 0.0585 DELD=-0.0004 DELDD= 0.0000 SIGT=   3635.0 SIGAX=   1723.2 SIGR=   -188.7 SIGE=   2341.6
T=0.1698 X=43.298 XD=  -185.17 XDD= -66502.7 P1=   889.47 P1D=-3885951.0 P2=   228.59 P2D=  105279.8 P3=   228.59 P3D=       0.0
DELA= 0.0015 DELAD= 0.1551 DELD=-0.0004 DELDD=-0.0635 SIGT=   4403.3 SIGAX=   2087.3 SIGR=   -228.6 SIGE=   2836.4
T=0.1718 X=42.818 XD=  -284.10 XDD= -35582.8 P1=   889.47 P1D=-4417347.0 P2=   324.88 P2D=  122054.6 P3=   324.88 P3D=       0.0
DELA= 0.0021 DELAD= 0.4326 DELD=-0.0006 DELDD=-0.0808 SIGT=   6258.1 SIGAX=   2966.6 SIGR=   -324.9 SIGE=   4031.2
T=0.1738 X=42.191 XD=  -337.69 XDD= -19932.7 P1=   889.47 P1D=-4455623.0 P2=   453.91 P2D=  138239.5 P3=   453.91 P3D=       0.0
DELA= 0.0030 DELAD= 0.3523 DELD=-0.0008 DELDD=-0.1185 SIGT=   8743.7 SIGAX=   4144.9 SIGR=   -453.9 SIGE=   5632.4
T=0.1758 X=41.480 XD=  -371.01 XDD= -14870.1 P1=   889.47 P1D=-4218163.0 P2=   601.94 P2D=  135182.1 P3=   601.94 P3D=       0.0
DELA= 0.0039 DELAD= 0.5354 DELD=-0.0011 DELDD=-0.1144 SIGT=  11595.2 SIGAX=   5496.6 SIGR=   -601.9 SIGE=   7469.2
T=0.1778 X=40.710 XD=  -397.93 XDD= -12173.9 P1=   889.47 P1D=-3742950.0 P2=   765.15 P2D=  133552.3 P3=   765.15 P3D=       0.0
DELA= 0.0050 DELAD= 0.4992 DELD=-0.0014 DELDD=-0.1352 SIGT=  14739.0 SIGAX=   6986.9 SIGR=   -765.1 SIGE=   9494.3
T=0.1798 X=39.892 XD=  -419.90 XDD=  -9909.6 P1=   928.60 P1D=       0.0 P2=   928.60 P2D=   40501.3 P3=   928.60 P3D=       0.0
DELA= 0.0061 DELAD= 0.2252 DELD=-0.0017 DELDD=-0.1404 SIGT=  17887.6 SIGAX=   8479.5 SIGR=   -928.6 SIGE=  11522.5
T=0.1818 X=39.033 XD=  -437.83 XDD=  -8105.2 P1=  1012.89 P1D=       0.0 P2=  1012.89 P2D=   49234.2 P3=  1012.89 P3D=       0.0
DELA= 0.0067 DELAD= 0.1522 DELD=-0.0019 DELDD=-0.0444 SIGT=  19511.3 SIGAX=   9249.2 SIGR=  -1012.9 SIGE=  12568.5
T=0.1838 X=38.142 XD=  -452.45 XDD=  -6581.3 P1=  1101.76 P1D=       0.0 P2=  1101.76 P2D=   35971.9 P3=  1101.76 P3D=       0.0
DELA= 0.0072 DELAD= 0.4882 DELD=-0.0020 DELDD=-0.0573 SIGT=  21223.1 SIGAX=  10060.7 SIGR=  -1101.8 SIGE=  13671.1
T=0.1858 X=37.224 XD=  -464.26 XDD=  -5290.7 P1=  1193.92 P1D=       0.0 P2=  1193.92 P2D=   56017.5 P3=  1193.92 P3D=       0.0
DELA= 0.0078 DELAD= 0.0649 DELD=-0.0022 DELDD=-0.0976 SIGT=  22998.5 SIGAX=  10902.3 SIGR=  -1193.9 SIGE=  14814.8
T=0.1878 X=36.286 XD=  -473.69 XDD=  -4188.8 P1=  1287.74 P1D=       0.0 P2=  1287.74 P2D=   42115.2 P3=  1287.74 P3D=       0.0
DELA= 0.0085 DELAD= 0.4305 DELD=-0.0024 DELDD=-0.0571 SIGT=  24805.7 SIGAX=  11759.0 SIGR=  -1287.7 SIGE=  15978.9
T=0.1898 X=35.331 XD=  -481.08 XDD=  -3241.9 P1=  1385.42 P1D=       0.0 P2=  1385.42 P2D=   48629.4 P3=  1385.42 P3D=       0.0
DELA= 0.0091 DELAD= 0.3076 DELD=-0.0026 DELDD=-0.0765 SIGT=  26687.4 SIGAX=  12651.0 SIGR=  -1385.4 SIGE=  17191.0
T=0.1918 X=34.362 XD=  -486.71 XDD=  -2425.2 P1=  1483.82 P1D=       0.0 P2=  1483.82 P2D=   55704.6 P3=  1483.82 P3D=       0.0
DELA= 0.0097 DELAD= 0.1707 DELD=-0.0028 DELDD=-0.0949 SIGT=  28582.8 SIGAX=  13549.5 SIGR=  -1483.8 SIGE=  18411.9
T=0.1938 X=33.384 XD=  -490.82 XDD=  -1713.1 P1=  1584.21 P1D=       0.0 P2=  1584.21 P2D=   43023.1 P3=  1584.21 P3D=       0.0
DELA= 0.0104 DELAD= 0.4862 DELD=-0.0029 DELDD=-0.0557 SIGT=  30516.7 SIGAX=  14466.2 SIGR=  -1584.2 SIGE=  19657.7
T=0.1958 X=32.399 XD=  -493.59 XDD=  -1090.1 P1=  1686.68 P1D=       0.0 P2=  1686.68 P2D=   55659.8 P3=  1686.68 P3D=       0.0
DELA= 0.0111 DELAD= 0.2133 DELD=-0.0031 DELDD=-0.0944 SIGT=  32490.4 SIGAX=  15401.9 SIGR=  -1686.7 SIGE=  20929.1
T=0.1978 X=31.410 XD=  -495.20 XDD=   -541.2 P1=  1789.11 P1D=       0.0 P2=  1789.11 P2D=   53374.4 P3=  1789.11 P3D=       0.0
DELA= 0.0117 DELAD= 0.2821 DELD=-0.0033 DELDD=-0.0847 SIGT=  34463.6 SIGAX=  16337.2 SIGR=  -1789.1 SIGE=  22200.1
T=0.1998 X=30.419 XD=  -495.77 XDD=    -52.4 P1=  1893.28 P1D=       0.0 P2=  1893.28 P2D=   46206.7 P3=  1893.28 P3D=       0.0
DELA= 0.0124 DELAD= 0.4545 DELD=-0.0035 DELDD=-0.0636 SIGT=  36470.2 SIGAX=  17288.5 SIGR=  -1893.3 SIGE=  23492.7
T=0.2018 X=29.427 XD=  -495.42 XDD=    383.7 P1=  1998.27 P1D=       0.0 P2=  1998.27 P2D=   57656.3 P3=  1998.27 P3D=       0.0
DELA= 0.0131 DELAD= 0.2068 DELD=-0.0037 DELDD=-0.0983 SIGT=  38492.7 SIGAX=  18247.2 SIGR=  -1998.3 SIGE=  24795.5
T=0.2038 X=28.437 XD=  -494.24 XDD=    776.4 P1=  2102.97 P1D=       0.0 P2=  2102.97 P2D=   52811.6 P3=  2102.97 P3D=       0.0
DELA= 0.0138 DELAD= 0.3220 DELD=-0.0039 DELDD=-0.0820 SIGT=  40509.5 SIGAX=  19203.3 SIGR=  -2103.0 SIGE=  26094.7
T=0.2058 X=27.450 XD=  -492.32 XDD=   1133.5 P1=  2208.80 P1D=       0.0 P2=  2208.80 P2D=   48034.4 P3=  2208.80 P3D=       0.0
DELA= 0.0145 DELAD= 0.4305 DELD=-0.0041 DELDD=-0.0680 SIGT=  42548.0 SIGAX=  20169.6 SIGR=  -2208.8 SIGE=  27407.8
T=0.2078 X=26.468 XD=  -489.71 XDD=   1458.6 P1=  2314.83 P1D=       0.0 P2=  2314.83 P2D=   57226.4 P3=  2314.83 P3D=       0.0
DELA= 0.0152 DELAD= 0.2312 DELD=-0.0043 DELDD=-0.0963 SIGT=  44590.6 SIGAX=  21137.9 SIGR=  -2314.8 SIGE=  28723.6
T=0.2098 X=25.491 XD=  -486.48 XDD=   1757.3 P1=  2420.26 P1D=       0.0 P2=  2420.26 P2D=   53741.8 P3=  2420.26 P3D=       0.0
DELA= 0.0159 DELAD= 0.3078 DELD=-0.0045 DELDD=-0.0844 SIGT=  46621.5 SIGAX=  22100.6 SIGR=  -2420.3 SIGE=  30031.8
T=0.2118 X=24.521 XD=  -482.68 XDD=   2034.2 P1=  2526.16 P1D=       0.0 P2=  2526.16 P2D=   48318.9 P3=  2526.16 P3D=       0.0
DELA= 0.0166 DELAD= 0.4214 DELD=-0.0047 DELDD=-0.0690 SIGT=  48661.3 SIGAX=  23067.6 SIGR=  -2526.2 SIGE=  31345.8
T=0.2138 X=23.560 XD=  -478.34 XDD=   2291.2 P1=  2631.99 P1D=       0.0 P2=  2631.99 P2D=   55088.7 P3=  2631.99 P3D=       0.0
DELA= 0.0173 DELAD= 0.2725 DELD=-0.0049 DELDD=-0.0906 SIGT=  50700.0 SIGAX=  24034.0 SIGR=  -2632.0 SIGE=  32659.0
T=0.2158 X=22.608 XD=  -473.51 XDD=   2531.1 P1=  2736.91 P1D=       0.0 P2=  2736.91 P2D=   55111.2 P3=  2736.91 P3D=       0.0
DELA= 0.0180 DELAD= 0.2678 DELD=-0.0051 DELDD=-0.0894 SIGT=  52720.9 SIGAX=  24992.0 SIGR=  -2736.9 SIGE=  33960.8
T=0.2178 X=21.666 XD=  -468.21 XDD=   2757.2 P1=  2841.55 P1D=       0.0 P2=  2841.55 P2D=   48658.1 P3=  2841.55 P3D=       0.0
DELA= 0.0187 DELAD= 0.3958 DELD=-0.0053 DELDD=-0.0705 SIGT=  54736.8 SIGAX=  25947.6 SIGR=  -2841.6 SIGE=  35259.4
T=0.2198 X=20.735 XD=  -462.47 XDD=   2970.5 P1=  2945.99 P1D=       0.0 P2=  2945.99 P2D=   51256.8 P3=  2945.99 P3D=       0.0
DELA= 0.0193 DELAD= 0.3322 DELD=-0.0055 DELDD=-0.0793 SIGT=  56748.5 SIGAX=  26901.3 SIGR=  -2946.0 SIGE=  36555.2
T=0.2218 X=19.816 XD=  -455.84 XDD=   5378.3 P1=  3014.76 P1D=       0.0 P2=  3014.76 P2D=   13237.6 P3=  3947.07 P3D=1742057.0
DELA= 0.0198 DELAD=-0.5388 DELD=-0.0056 DELDD=-0.2833 SIGT=  58073.3 SIGAX=  27529.3 SIGR=  -3014.8 SIGE=  37408.6
T=0.2238 X=18.919 XD=  -439.12 XDD=  10016.1 P1=  3066.78 P1D=       0.0 P2=  3066.78 P2D=   21094.2 P3=  5619.99 P3D= 359613.4
DELA= 0.0202 DELAD= 0.6917 DELD=-0.0057 DELDD= 0.0667 SIGT=  59075.3 SIGAX=  28004.3 SIGR=  -3066.8 SIGE=  38054.1
T=0.2258 X=18.062 XD=  -417.79 XDD=  11052.6 P1=  3157.68 P1D=       0.0 P2=  3157.68 P2D=   19764.0 P3=  6023.12 P3D= 103130.0
DELA= 0.0207 DELAD= 0.7949 DELD=-0.0059 DELDD=-0.0066 SIGT=  60826.2 SIGAX=  28834.3 SIGR=  -3157.7 SIGE=  39182.0
T=0.2278 X=17.248 XD=  -395.35 XDD=  11315.6 P1=  3251.29 P1D=       0.0 P2=  3251.29 P2D=   61214.1 P3=  6148.50 P3D=  37608.1
```

```
DELA= 0.0213 DELAD=-0.0262 DELD=-0.0060 DELDD=-0.1213 SIGT=   62629.6 SIGAX=   29689.2 SIGR=   -3251.3 SIGE=   40343.6
T=0.2298 X=16.480 XD=  -372.65 XDD=  11354.3 P1=  3339.42 P1D=        0.0 P2=  3339.42 P2D=   69263.9 P3=  6191.90 P3D=   11659.1
DELA= 0.0219 DELAD=-0.2282 DELD=-0.0062 DELDD=-0.1478 SIGT=   64327.1 SIGAX=   30493.9 SIGR=   -3339.4 SIGE=   41437.1
T=0.2318 X=15.757 XD=  -350.00 XDD=  11286.5 P1=  3423.39 P1D=        0.0 P2=  3423.39 P2D=   34695.0 P3=  6196.68 P3D=   -4990.6
DELA= 0.0225 DELAD= 0.3928 DELD=-0.0064 DELDD=-0.0392 SIGT=   65944.6 SIGAX=   31260.6 SIGR=   -3423.4 SIGE=   42479.0
T=0.2338 X=15.079 XD=  -327.56 XDD=  11142.4 P1=  3505.05 P1D=        0.0 P2=  3505.05 P2D=   15280.7 P3=  6173.00 P3D=  -17383.1
DELA= 0.0230 DELAD= 0.7076 DELD=-0.0065 DELDD= 0.0148 SIGT=   67517.7 SIGAX=   32006.4 SIGR=   -3505.1 SIGE=   43492.3
T=0.2358 X=14.446 XD=  -305.47 XDD=  10935.7 P1=  3582.83 P1D=        0.0 P2=  3582.83 P2D=   34904.3 P3=  6124.32 P3D=  -27847.4
DELA= 0.0235 DELAD= 0.2661 DELD=-0.0067 DELDD=-0.0552 SIGT=   69016.0 SIGAX=   32716.6 SIGR=   -3582.8 SIGE=   44457.5
T=0.2378 X=13.857 XD=  -283.85 XDD=  10674.3 P1=  3654.51 P1D=        0.0 P2=  3654.51 P2D=   54579.9 P3=  6053.14 P3D=  -38274.4
DELA= 0.0240 DELAD=-0.1683 DELD=-0.0068 DELDD=-0.1182 SIGT=   70396.7 SIGAX=   33371.2 SIGR=   -3654.5 SIGE=   45346.9
T=0.2398 X=13.311 XD=  -262.81 XDD=  10363.1 P1=  3720.54 P1D=        0.0 P2=  3720.54 P2D=   42336.1 P3=  5962.33 P3D=  -48229.3
DELA= 0.0244 DELAD= 0.0123 DELD=-0.0069 DELDD=-0.0795 SIGT=   71668.6 SIGAX=   33974.1 SIGR=   -3720.5 SIGE=   46166.2
T=0.2418 X=12.805 XD=  -242.44 XDD=  10009.6 P1=  3782.84 P1D=        0.0 P2=  3782.84 P2D=   17611.2 P3=  5855.07 P3D=  -55875.8
DELA= 0.0249 DELAD= 0.4280 DELD=-0.0070 DELDD=-0.0049 SIGT=   72868.7 SIGAX=   34543.0 SIGR=   -3782.8 SIGE=   46939.2
T=0.2438 X=12.340 XD=  -222.81 XDD=   9624.7 P1=  3841.88 P1D=        0.0 P2=  3841.88 P2D=   13542.3 P3=  5734.77 P3D=  -60593.8
DELA= 0.0252 DELAD= 0.4460 DELD=-0.0071 DELDD= 0.0007 SIGT=   74006.1 SIGAX=   35082.1 SIGR=   -3841.9 SIGE=   47671.9
T=0.2458 X=11.914 XD=  -203.97 XDD=   9220.3 P1=  3896.42 P1D=        0.0 P2=  3896.42 P2D=   29348.7 P3=  5605.04 P3D=  -63510.8
DELA= 0.0256 DELAD= 0.0891 DELD=-0.0073 DELDD=-0.0543 SIGT=   75056.6 SIGAX=   35580.1 SIGR=   -3896.4 SIGE=   48348.6
T=0.2478 X=11.524 XD=  -185.96 XDD=   8805.4 P1=  3945.58 P1D=        0.0 P2=  3945.58 P2D=   37889.5 P3=  5469.52 P3D=  -65706.3
DELA= 0.0259 DELAD=-0.1242 DELD=-0.0073 DELDD=-0.0823 SIGT=   76003.6 SIGAX=   36029.1 SIGR=   -3945.6 SIGE=   48958.7
T=0.2498 X=11.169 XD=  -168.77 XDD=   8387.9 P1=  3990.09 P1D=        0.0 P2=  3990.09 P2D=   26368.2 P3=  5331.70 P3D=  -66807.1
DELA= 0.0262 DELAD= 0.0439 DELD=-0.0074 DELDD=-0.0474 SIGT=   76861.0 SIGAX=   36435.5 SIGR=   -3990.1 SIGE=   49510.9
T=0.2518 X=10.848 XD=  -152.42 XDD=   7975.6 P1=  4031.17 P1D=        0.0 P2=  4031.17 P2D=   10201.4 P3=  5194.82 P3D=  -65854.1
DELA= 0.0265 DELAD= 0.2992 DELD=-0.0075 DELDD= 0.0006 SIGT=   77652.4 SIGAX=   36810.6 SIGR=   -4031.2 SIGE=   50020.7
T=0.2538 X=10.559 XD=  -136.88 XDD=   7577.1 P1=  4069.07 P1D=        0.0 P2=  4069.07 P2D=    8019.3 P3=  5061.60 P3D=  -62681.8
DELA= 0.0267 DELAD= 0.2904 DELD=-0.0076 DELDD= 0.0025 SIGT=   78382.3 SIGAX=   37156.7 SIGR=   -4069.1 SIGE=   50490.9
T=0.2557 X=10.300 XD=  -122.12 XDD=   7199.7 P1=  4103.09 P1D=        0.0 P2=  4103.09 P2D=   17936.1 P3=  4934.43 P3D=  -58426.8
DELA= 0.0269 DELAD= 0.0562 DELD=-0.0076 DELDD=-0.0336 SIGT=   79037.6 SIGAX=   37467.3 SIGR=   -4103.1 SIGE=   50913.0
T=0.2577 X=10.070 XD=  -108.08 XDD=   6848.4 P1=  4132.76 P1D=        0.0 P2=  4132.76 P2D=   23639.1 P3=  4815.22 P3D=  -54161.2
DELA= 0.0271 DELAD=-0.0941 DELD=-0.0077 DELDD=-0.0530 SIGT=   79609.2 SIGAX=   37738.3 SIGR=   -4132.8 SIGE=   51281.3
T=0.2597 X= 9.867 XD=   -94.72 XDD=   6526.2 P1=  4158.62 P1D=        0.0 P2=  4158.62 P2D=   16652.1 P3=  4705.62 P3D=  -49872.9
DELA= 0.0273 DELAD=-0.0038 DELD=-0.0077 DELDD=-0.0316 SIGT=   80107.4 SIGAX=   37974.4 SIGR=   -4158.6 SIGE=   51602.2
T=0.2617 X= 9.691 XD=   -81.97 XDD=   6235.7 P1=  4181.47 P1D=        0.0 P2=  4181.47 P2D=    5411.2 P3=  4606.78 P3D=  -44730.1
DELA= 0.0275 DELAD= 0.1662 DELD=-0.0078 DELDD= 0.0017 SIGT=   80547.5 SIGAX=   38183.1 SIGR=   -4181.5 SIGE=   51885.7
T=0.2637 X= 9.539 XD=   -69.77 XDD=   5979.5 P1=  4201.60 P1D=        0.0 P2=  4201.60 P2D=    1915.8 P3=  4519.50 P3D=  -38248.8
DELA= 0.0276 DELAD= 0.1905 DELD=-0.0078 DELDD= 0.0080 SIGT=   80935.3 SIGAX=   38366.9 SIGR=   -4201.6 SIGE=   52135.5
T=0.2657 X= 9.411 XD=   -58.04 XDD=   5759.9 P1=  4218.65 P1D=        0.0 P2=  4218.65 P2D=    7372.9 P3=  4444.32 P3D=  -31179.8
DELA= 0.0277 DELAD= 0.0501 DELD=-0.0079 DELDD=-0.0118 SIGT=   81263.7 SIGAX=   38522.6 SIGR=   -4218.7 SIGE=   52347.0
T=0.2677 X= 9.307 XD=   -46.72 XDD=   5577.8 P1=  4232.31 P1D=        0.0 P2=  4232.31 P2D=   11918.9 P3=  4381.62 P3D=  -24717.6
DELA= 0.0278 DELAD=-0.0719 DELD=-0.0079 DELDD=-0.0289 SIGT=   81526.8 SIGAX=   38647.3 SIGR=   -4232.3 SIGE=   52516.5
T=0.2697 X= 9.224 XD=   -35.71 XDD=   5433.1 P1=  4242.75 P1D=        0.0 P2=  4242.75 P2D=    8801.1 P3=  4331.65 P3D=  -19273.0
DELA= 0.0279 DELAD=-0.0486 DELD=-0.0079 DELDD=-0.0205 SIGT=   81727.9 SIGAX=   38742.6 SIGR=   -4242.7 SIGE=   52646.0
T=0.2717 X= 9.163 XD=   -24.96 XDD=   5325.7 P1=  4250.46 P1D=        0.0 P2=  4250.46 P2D=    1194.6 P3=  4294.59 P3D=  -14137.5
DELA= 0.0279 DELAD= 0.0594 DELD=-0.0079 DELDD= 0.0022 SIGT=   81876.5 SIGAX=   38813.1 SIGR=   -4250.5 SIGE=   52741.7
T=0.2737 X= 9.124 XD=   -14.39 XDD=   5256.1 P1=  4255.70 P1D=        0.0 P2=  4255.70 P2D=   -2906.9 P3=  4270.48 P3D=   -8045.8
DELA= 0.0279 DELAD= 0.1005 DELD=-0.0079 DELDD= 0.0115 SIGT=   81977.4 SIGAX=   38860.9 SIGR=   -4255.7 SIGE=   52806.8
T=0.2757 X= 9.106 XD=    -3.92 XDD=   5224.8 P1=  4258.27 P1D=        0.0 P2=  4258.27 P2D=    -794.1 P3=  4259.36 P3D=   -1981.9
DELA= 0.0280 DELAD= 0.0270 DELD=-0.0079 DELDD= 0.0026 SIGT=   82026.8 SIGAX=   38884.3 SIGR=   -4258.3 SIGE=   52838.6
T=0.2777 X= 9.107 XD=     3.80 XDD=   3039.2 P1=  4258.16 P1D=        0.0 P2=  4258.16 P2D=    2859.3 P3=  4257.13 P3D=    1835.3
DELA= 0.0280 DELAD=-0.0651 DELD=-0.0079 DELDD=-0.0092 SIGT=   82024.7 SIGAX=   38883.4 SIGR=   -4258.2 SIGE=   52837.2
T=0.2797 X= 9.120 XD=     9.87 XDD=   3027.3 P1=  4256.32 P1D=        0.0 P2=  4256.32 P2D=    1685.5 P3=  4249.93 P3D=   -2755.8
DELA= 0.0280 DELAD=-0.0597 DELD=-0.0079 DELDD=-0.0062 SIGT=   81989.4 SIGAX=   38866.6 SIGR=   -4256.3 SIGE=   52814.5
T=0.2817 X= 9.146 XD=    15.90 XDD=   3001.3 P1=  4253.16 P1D=        0.0 P2=  4253.16 P2D=   -2738.6 P3=  4236.98 P3D=   -7635.3
DELA= 0.0279 DELAD= 0.0060 DELD=-0.0079 DELDD= 0.0061 SIGT=   81928.4 SIGAX=   38837.7 SIGR=   -4253.2 SIGE=   52775.2
T=0.2837 X= 9.184 XD=    21.86 XDD=   2962.3 P1=  4248.82 P1D=        0.0 P2=  4248.82 P2D=   -5259.2 P3=  4218.42 P3D=   -9977.8
DELA= 0.0279 DELAD= 0.0355 DELD=-0.0079 DELDD= 0.0125 SIGT=   81844.8 SIGAX=   38798.0 SIGR=   -4248.8 SIGE=   52721.3
T=0.2857 X= 9.233 XD=    27.74 XDD=   2912.6 P1=  4243.18 P1D=        0.0 P2=  4243.18 P2D=   -4299.4 P3=  4194.60 P3D=  -11567.6
DELA= 0.0279 DELAD= 0.0007 DELD=-0.0079 DELDD= 0.0088 SIGT=   81736.3 SIGAX=   38746.6 SIGR=   -4243.2 SIGE=   52651.4
T=0.2877 X= 9.295 XD=    33.51 XDD=   2853.8 P1=  4236.10 P1D=        0.0 P2=  4236.10 P2D=   -2356.5 P3=  4166.08 P3D=  -13503.1
DELA= 0.0278 DELAD=-0.0523 DELD=-0.0079 DELDD= 0.0015 SIGT=   81599.9 SIGAX=   38681.9 SIGR=   -4236.1 SIGE=   52563.6
T=0.2897 X= 9.367 XD=    39.15 XDD=   2787.1 P1=  4227.55 P1D=        0.0 P2=  4227.55 P2D=   -2603.9 P3=  4133.50 P3D=  -15803.2
DELA= 0.0278 DELAD=-0.0642 DELD=-0.0079 DELDD= 0.0006 SIGT=   81435.2 SIGAX=   38603.9 SIGR=   -4227.6 SIGE=   52457.5
T=0.2917 X= 9.451 XD=    44.65 XDD=   2713.9 P1=  4217.71 P1D=        0.0 P2=  4217.71 P2D=   -5189.7 P3=  4097.54 P3D=  -17814.0
DELA= 0.0277 DELAD=-0.0310 DELD=-0.0078 DELDD= 0.0089 SIGT=   81245.6 SIGAX=   38514.0 SIGR=   -4217.7 SIGE=   52335.4
```

```
T=0.2937 X= 9.546 XD=    49.99 XDD=   2635.8 P1=  4206.71 P1D=         0.0 P2=  4206.71 P2D=   -7459.6 P3=  4058.81 P3D= -19100.5
DELA= 0.0276 DELAD=-0.0044 DELD=-0.0078 DELDD= 0.0146 SIGT=   81033.7 SIGAX=   38413.5 SIGR=   -4206.7 SIGE=   52198.8
T=0.2957 X= 9.651 XD=    55.18 XDD=   2554.3 P1=  4194.54 P1D=         0.0 P2=  4194.54 P2D=   -7466.2 P3=  4017.91 P3D= -19824.0
DELA= 0.0275 DELAD=-0.0196 DELD=-0.0078 DELDD= 0.0135 SIGT=   80799.2 SIGAX=   38302.4 SIGR=   -4194.5 SIGE=   52047.8
T=0.2977 X= 9.766 XD=    60.21 XDD=   2471.3 P1=  4181.12 P1D=         0.0 P2=  4181.12 P2D=   -6372.4 P3=  3975.48 P3D= -20402.3
DELA= 0.0275 DELAD=-0.0549 DELD=-0.0078 DELDD= 0.0091 SIGT=   80540.7 SIGAX=   38179.9 SIGR=   -4181.1 SIGE=   51881.3
T=0.2997 X= 9.892 XD=    65.06 XDD=   2387.7 P1=  4166.45 P1D=         0.0 P2=  4166.45 P2D=   -6232.2 P3=  3932.04 P3D= -20947.9
DELA= 0.0274 DELAD=-0.0715 DELD=-0.0078 DELDD= 0.0082 SIGT=   80258.1 SIGAX=   38045.9 SIGR=   -4166.4 SIGE=   51699.2
T=0.3017 X=10.026 XD=    69.75 XDD=   2304.7 P1=  4150.60 P1D=         0.0 P2=  4150.60 P2D=   -7818.2 P3=  3888.06 P3D= -21342.3
DELA= 0.0273 DELAD=-0.0559 DELD=-0.0077 DELDD= 0.0119 SIGT=   79952.9 SIGAX=   37901.2 SIGR=   -4150.6 SIGE=   51502.6
T=0.3037 X=10.171 XD=    74.28 XDD=   2223.1 P1=  4133.73 P1D=         0.0 P2=  4133.73 P2D=   -9658.6 P3=  3843.99 P3D= -21412.4
DELA= 0.0272 DELAD=-0.0350 DELD=-0.0077 DELDD= 0.0166 SIGT=   79627.9 SIGAX=   37747.1 SIGR=   -4133.7 SIGE=   51293.2
T=0.3057 X=10.323 XD=    78.44 XDD=   2143.9 P1=  4115.86 P1D=         0.0 P2=  4115.86 P2D=   -9995.9 P3=  3800.12 P3D= -21194.7
DELA= 0.0270 DELAD=-0.0416 DELD=-0.0077 DELDD= 0.0169 SIGT=   79283.6 SIGAX=   37583.9 SIGR=   -4115.9 SIGE=   51071.5
T=0.3077 X=10.485 XD=    82.85 XDD=   2067.7 P1=  4096.95 P1D=         0.0 P2=  4096.95 P2D=   -9456.7 P3=  3756.72 P3D= -20878.6
DELA= 0.0269 DELAD=-0.0646 DELD=-0.0076 DELDD= 0.0140 SIGT=   78919.3 SIGAX=   37411.2 SIGR=   -4096.9 SIGE=   50836.8
T=0.3097 X=10.655 XD=    86.91 XDD=   1995.0 P1=  4077.02 P1D=         0.0 P2=  4077.02 P2D=   -9412.9 P3=  3714.03 P3D= -20582.7
DELA= 0.0268 DELAD=-0.0771 DELD=-0.0076 DELDD= 0.0136 SIGT=   78535.6 SIGAX=   37229.3 SIGR=   -4077.0 SIGE=   50589.7
T=0.3117 X=10.832 XD=    90.83 XDD=   1925.9 P1=  4056.13 P1D=         0.0 P2=  4056.13 P2D=  -10371.7 P3=  3672.16 P3D= -20288.2
DELA= 0.0266 DELAD=-0.0707 DELD=-0.0075 DELDD= 0.0160 SIGT=   78133.1 SIGAX=   37038.5 SIGR=   -4056.1 SIGE=   50330.4
T=0.3137 X=11.018 XD=    94.61 XDD=   1860.6 P1=  4034.35 P1D=         0.0 P2=  4034.35 P2D=  -11623.4 P3=  3631.21 P3D= -19898.8
DELA= 0.0265 DELAD=-0.0587 DELD=-0.0075 DELDD= 0.0186 SIGT=   77713.4 SIGAX=   36839.6 SIGR=   -4034.3 SIGE=   50060.1
T=0.3157 X=11.211 XD=    98.27 XDD=   1799.2 P1=  4011.71 P1D=         0.0 P2=  4011.71 P2D=  -12132.4 P3=  3591.20 P3D= -19417.3
DELA= 0.0263 DELAD=-0.0598 DELD=-0.0075 DELDD= 0.0199 SIGT=   77277.5 SIGAX=   36632.9 SIGR=   -4011.7 SIGE=   49779.2
T=0.3177 X=11.411 XD=   101.81 XDD=   1741.8 P1=  3988.23 P1D=         0.0 P2=  3988.23 P2D=  -11919.8 P3=  3552.16 P3D= -18925.2
DELA= 0.0262 DELAD=-0.0744 DELD=-0.0074 DELDD= 0.0183 SIGT=   76825.1 SIGAX=   36418.5 SIGR=   -3988.2 SIGE=   49487.8
T=0.3197 X=11.618 XD=   105.24 XDD=   1688.2 P1=  3963.88 P1D=         0.0 P2=  3963.88 P2D=  -11838.6 P3=  3514.06 P3D= -18514.5
DELA= 0.0260 DELAD=-0.0861 DELD=-0.0074 DELDD= 0.0174 SIGT=   76356.0 SIGAX=   36196.1 SIGR=   -3963.9 SIGE=   49185.7
T=0.3217 X=11.832 XD=   108.56 XDD=   1638.2 P1=  3938.71 P1D=         0.0 P2=  3938.71 P2D=  -12513.1 P3=  3476.88 P3D= -18159.4
DELA= 0.0259 DELAD=-0.0832 DELD=-0.0073 DELDD= 0.0188 SIGT=   75871.2 SIGAX=   35966.3 SIGR=   -3938.7 SIGE=   48873.4
T=0.3237 X=12.052 XD=   111.79 XDD=   1591.7 P1=  3912.79 P1D=         0.0 P2=  3912.79 P2D=  -13468.2 P3=  3440.57 P3D= -17798.9
DELA= 0.0257 DELAD=-0.0742 DELD=-0.0073 DELDD= 0.0218 SIGT=   75372.0 SIGAX=   35729.7 SIGR=   -3912.8 SIGE=   48551.8
T=0.3257 X=12.279 XD=   114.93 XDD=   1548.5 P1=  3886.17 P1D=         0.0 P2=  3886.17 P2D=  -13859.3 P3=  3405.05 P3D= -17413.1
DELA= 0.0255 DELAD=-0.0762 DELD=-0.0072 DELDD= 0.0221 SIGT=   74859.1 SIGAX=   35486.5 SIGR=   -3886.2 SIGE=   48221.4
T=0.3277 X=12.512 XD=   117.98 XDD=   1508.3 P1=  3858.82 P1D=         0.0 P2=  3858.82 P2D=  -13747.0 P3=  3370.25 P3D= -17062.6
DELA= 0.0253 DELAD=-0.0872 DELD=-0.0072 DELDD= 0.0213 SIGT=   74332.2 SIGAX=   35236.8 SIGR=   -3858.8 SIGE=   47882.0
T=0.3297 X=12.751 XD=   120.96 XDD=   1471.0 P1=  3830.75 P1D=         0.0 P2=  3830.75 P2D=  -13798.3 P3=  3336.11 P3D= -16790.9
DELA= 0.0252 DELAD=-0.0951 DELD=-0.0071 DELDD= 0.0203 SIGT=   73791.5 SIGAX=   34980.4 SIGR=   -3830.7 SIGE=   47533.7
T=0.3317 X=12.995 XD=   123.87 XDD=   1436.4 P1=  3801.98 P1D=         0.0 P2=  3801.98 P2D=  -14362.2 P3=  3302.54 P3D= -16584.2
DELA= 0.0250 DELAD=-0.0923 DELD=-0.0071 DELDD= 0.0222 SIGT=   73237.4 SIGAX=   34717.8 SIGR=   -3802.0 SIGE=   47176.7
T=0.3337 X=13.246 XD=   126.70 XDD=   1404.0 P1=  3772.58 P1D=         0.0 P2=  3772.58 P2D=  -15124.9 P3=  3269.48 P3D= -16386.5
DELA= 0.0248 DELAD=-0.0860 DELD=-0.0070 DELDD= 0.0240 SIGT=   72671.1 SIGAX=   34449.3 SIGR=   -3772.6 SIGE=   46812.0
T=0.3357 X=13.502 XD=   129.48 XDD=   1373.9 P1=  3742.57 P1D=         0.0 P2=  3742.57 P2D=  -15370.7 P3=  3236.84 P3D= -16182.0
DELA= 0.0246 DELAD=-0.0888 DELD=-0.0070 DELDD= 0.0248 SIGT=   72093.0 SIGAX=   34175.2 SIGR=   -3742.6 SIGE=   46439.6
T=0.3377 X=13.764 XD=   132.20 XDD=   1345.7 P1=  3711.94 P1D=         0.0 P2=  3711.94 P2D=  -15396.9 P3=  3204.56 P3D= -16019.3
DELA= 0.0244 DELAD=-0.0968 DELD=-0.0069 DELDD= 0.0232 SIGT=   71502.9 SIGAX=   33895.5 SIGR=   -3711.9 SIGE=   46059.5
T=0.3397 X=14.031 XD=   134.86 XDD=   1319.3 P1=  3680.69 P1D=         0.0 P2=  3680.69 P2D=  -15500.0 P3=  3172.56 P3D= -15912.8
DELA= 0.0242 DELAD=-0.1019 DELD=-0.0069 DELDD= 0.0236 SIGT=   70901.0 SIGAX=   33610.2 SIGR=   -3680.7 SIGE=   45671.7
T=0.3417 X=14.303 XD=   137.47 XDD=   1294.4 P1=  3648.85 P1D=         0.0 P2=  3648.85 P2D=  -16002.9 P3=  3140.80 P3D= -15857.0
DELA= 0.0240 DELAD=-0.0992 DELD=-0.0068 DELDD= 0.0251 SIGT=   70287.6 SIGAX=   33319.4 SIGR=   -3648.8 SIGE=   45276.6
T=0.3437 X=14.581 XD=   140.04 XDD=   1270.9 P1=  3616.46 P1D=         0.0 P2=  3616.46 P2D=  -16552.1 P3=  3109.20 P3D= -15800.9
DELA= 0.0238 DELAD=-0.0960 DELD=-0.0067 DELDD= 0.0260 SIGT=   69663.7 SIGAX=   33023.7 SIGR=   -3616.5 SIGE=   44874.7
T=0.3457 X=14.863 XD=   142.56 XDD=   1248.7 P1=  3583.53 P1D=         0.0 P2=  3583.53 P2D=  -16715.3 P3=  3077.72 P3D= -15747.7
DELA= 0.0235 DELAD=-0.0998 DELD=-0.0067 DELDD= 0.0261 SIGT=   69029.4 SIGAX=   32723.0 SIGR=   -3583.5 SIGE=   44466.2
T=0.3477 X=15.151 XD=   145.03 XDD=   1227.6 P1=  3550.06 P1D=         0.0 P2=  3550.06 P2D=  -16726.3 P3=  3046.30 P3D= -15729.1
DELA= 0.0233 DELAD=-0.1060 DELD=-0.0066 DELDD= 0.0261 SIGT=   68384.7 SIGAX=   32417.3 SIGR=   -3550.1 SIGE=   44050.8
T=0.3497 X=15.443 XD=   147.47 XDD=   1207.4 P1=  3516.05 P1D=         0.0 P2=  3516.05 P2D=  -16935.8 P3=  3014.89 P3D= -15748.7
DELA= 0.0231 DELAD=-0.1089 DELD=-0.0065 DELDD= 0.0258 SIGT=   67729.6 SIGAX=   32106.8 SIGR=   -3516.1 SIGE=   43628.8
T=0.3516 X=15.741 XD=   149.86 XDD=   1188.1 P1=  3481.54 P1D=         0.0 P2=  3481.54 P2D=  -17362.0 P3=  2983.47 P3D= -15791.9
DELA= 0.0229 DELAD=-0.1068 DELD=-0.0065 DELDD= 0.0271 SIGT=   67064.7 SIGAX=   31791.6 SIGR=   -3481.5 SIGE=   43200.5
T=0.3536 X=16.043 XD=   152.22 XDD=   1169.4 P1=  3446.53 P1D=         0.0 P2=  3446.53 P2D=  -17742.2 P3=  2951.99 P3D= -15840.6
DELA= 0.0226 DELAD=-0.1059 DELD=-0.0064 DELDD= 0.0276 SIGT=   66390.4 SIGAX=   31472.0 SIGR=   -3446.5 SIGE=   42766.2
T=0.3556 X=16.349 XD=   154.54 XDD=   1151.3 P1=  3411.05 P1D=         0.0 P2=  3411.05 P2D=  -17965.1 P3=  2920.41 P3D= -15892.1
DELA= 0.0224 DELAD=-0.1073 DELD=-0.0063 DELDD= 0.0285 SIGT=   65707.0 SIGAX=   31148.0 SIGR=   -3411.1 SIGE=   42325.9
T=0.3576 X=16.660 XD=   156.82 XDD=   1133.8 P1=  3375.10 P1D=         0.0 P2=  3375.10 P2D=  -17997.6 P3=  2888.69 P3D= -15959.7
```

```
DELA= 0.0222 DELAD=-0.1130 DELD=-0.0063 DELDD= 0.0276 SIGT=   65014.4 SIGAX=   30819.7 SIGR=   -3375.1 SIGE=   41879.8
T=0.3596 X=16.976 XD=    159.07 XDD=    1116.6 P1=  3338.67 P1D=        0.0 P2=  3338.67 P2D=  -18204.3 P3=  2856.84 P3D= -16054.0
DELA= 0.0219 DELAD=-0.1144 DELD=-0.0062 DELDD= 0.0285 SIGT=   64312.7 SIGAX=   30487.0 SIGR=   -3338.7 SIGE=   41427.8
T=0.3616 X=17.296 XD=    161.29 XDD=    1099.8 P1=  3301.80 P1D=        0.0 P2=  3301.80 P2D=  -18581.0 P3=  2824.81 P3D= -16160.1
DELA= 0.0217 DELAD=-0.1128 DELD=-0.0061 DELDD= 0.0292 SIGT=   63602.4 SIGAX=   30150.3 SIGR=   -3301.8 SIGE=   40970.3
T=0.3636 X=17.620 XD=    163.47 XDD=    1083.3 P1=  3264.50 P1D=        0.0 P2=  3264.50 P2D=  -18870.2 P3=  2792.59 P3D= -16255.7
DELA= 0.0214 DELAD=-0.1130 DELD=-0.0061 DELDD= 0.0293 SIGT=   62883.9 SIGAX=   29809.7 SIGR=   -3264.5 SIGE=   40507.5
T=0.3656 X=17.949 XD=    165.62 XDD=    1067.0 P1=  3226.78 P1D=        0.0 P2=  3226.78 P2D=  -18913.6 P3=  2760.16 P3D= -16356.5
DELA= 0.0212 DELAD=-0.1174 DELD=-0.0060 DELDD= 0.0293 SIGT=   62157.3 SIGAX=   29465.3 SIGR=   -3226.8 SIGE=   40039.4
T=0.3676 X=18.282 XD=    167.74 XDD=    1050.8 P1=  3188.63 P1D=        0.0 P2=  3188.63 P2D=  -19025.4 P3=  2727.51 P3D= -16477.6
DELA= 0.0209 DELAD=-0.1205 DELD=-0.0059 DELDD= 0.0294 SIGT=   61422.5 SIGAX=   29117.0 SIGR=   -3188.6 SIGE=   39566.1
T=0.3696 X=18.619 XD=    169.82 XDD=    1034.8 P1=  3150.07 P1D=        0.0 P2=  3150.07 P2D=  -19320.0 P3=  2694.62 P3D= -16616.7
DELA= 0.0207 DELAD=-0.1196 DELD=-0.0059 DELDD= 0.0302 SIGT=   60679.8 SIGAX=   28764.9 SIGR=   -3150.1 SIGE=   39087.6
T=0.3716 X=18.961 XD=    171.87 XDD=    1018.8 P1=  3111.13 P1D=        0.0 P2=  3111.13 P2D=  -19678.7 P3=  2661.49 P3D= -16749.4
DELA= 0.0204 DELAD=-0.1176 DELD=-0.0058 DELDD= 0.0309 SIGT=   59929.7 SIGAX=   28409.3 SIGR=   -3111.1 SIGE=   38604.4
T=0.3736 X=19.306 XD=    173.90 XDD=    1002.8 P1=  3071.82 P1D=        0.0 P2=  3071.82 P2D=  -19757.6 P3=  2628.09 P3D= -16869.4
DELA= 0.0202 DELAD=-0.1212 DELD=-0.0057 DELDD= 0.0305 SIGT=   59172.4 SIGAX=   28050.3 SIGR=   -3071.8 SIGE=   38116.6
T=0.3756 X=19.656 XD=    175.88 XDD=     986.8 P1=  3032.13 P1D=        0.0 P2=  3032.13 P2D=  -19839.5 P3=  2594.43 P3D= -17008.7
DELA= 0.0199 DELAD=-0.1240 DELD=-0.0056 DELDD= 0.0310 SIGT=   58407.7 SIGAX=   27687.8 SIGR=   -3032.1 SIGE=   37624.1
   EC=                    -348.67212      EF=                     -78452.3750
```

DISTRIBUTION LIST

Commander
US Army Armament Research and
Development Command
ATTN: DRDAR-TSS (5)
DRDAR-LCW (25)
Dover, NJ 07801

Defense Documentation Center (12)
Cameron Station
Alexandria, VA 22314

US Army TRADOC Systems
Analysis Activity
ATTN: ATAA-SL (Tech Lib)
White Sands Missile Range, NM 88002

Commander
US Army Armament Materiel and
Readiness Command
ATTN: DRSAR-LEP-L
Rock Island, IL 61299

US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Weapon System Concept Team/CSL
ATTN: DRDAR-ACW
Aberdeen Proving Ground, MD 21010

Technical Library
ATTN: DRDAR-CLJ-L
Aberdeen Proving Ground, MD 21005

Technical Library
ATTN: DRDAR-TSB-S
Aberdeen Proving Ground, MD 21010

Technical Library
ATTN: DRDAR-LCB-TL
Benet Weapons Laboratory
Watervliet, NY 12189